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**NEW BRUNSWICK SUBSURFACE DRAINAGE PROJECT:
A STUDY OF WATER QUALITY EFFECTS OF INTENSIVE
AGRICULTURAL PRODUCTION**

INTERIM REPORT

PROJECT PERIOD

APRIL 1, 1987 TO MARCH 31, 1988

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ABSTRACT

This interim report presents the observations obtained by the Water Quality Branch, Atlantic Region for the first year of the New Brunswick Subsurface Drainage Project, a joint study with Agriculture Canada and the New Brunswick Department of Agriculture. Branch activities centered upon the investigation of pesticides in tile flow effluent. Brief discussions of sites, parameter selection, sampling, analytical procedures, and quality control are included.

The in-use pesticide dinoseb was observed in tile effluent from three potato fields with known dinoseb histories representing, carry over from 1986, at levels ranging from 1.1 $\mu\text{g/L}$ to 0.11 $\mu\text{g/L}$. Dinoseb was also reported in post-application tile effluent with a highest single observation of 44.0 $\mu\text{g/L}$. Subsequent samplings indicated diminishing dinoseb levels with time. Major ion data for tile effluent indicated shifts in calcium, alkalinity, potassium, nitrate, and total nitrogen concentrations as a result of fertilizer application.

Mass balance and transport calculations have indicated that the in-season sampling carried out by the Water Quality Branch has accounted for 0.001% of the dinoseb that was applied to two study fields.

SOMMAIRE

Ce rapport intérimaire présente les observations faites par la Direction de la qualité des eaux, région de l'Atlantique, au cours de la première année du "Projet de drainage souterrain du Nouveau-Brunswick". Cette étude est effectuée conjointement avec Agriculture Canada et le Département de l'Agriculture du Nouveau-Brunswick. Les activités de la Direction de la qualité des eaux dans cette étude sont surtout centrées sur une investigation concernant les pesticides dans l'effluent de drainage souterrain. De brèves discussions sur les sites étudiés, la sélection des paramètres, l'échantillonnage, les procédures analytiques et le contrôle de la qualité font partie de ce document.

Des échantillons d'effluent de drainage souterrain, recueillis avant l'arrosage de 1987, révélèrent la présence de dinosèbe, et ce, dans trois champs où ce pesticide fut utilisé en 1986. Les concentrations détectées variaient de 1,1 µg/L à 0,11 µg/L. Suite à l'application de 1987, le dinosèbe a aussi été détecté dans l'effluent, la plus forte concentration étant de 44,0 µg/L. Les échantillonnages subséquents ont démontré une diminution des concentrations de dinosèbe avec le temps. Des changements dans les concentrations de calcium, d'alcalinité, de potassium, de nitrate et d'azote total ont aussi été observés, suite à l'application d'engrais.

Il fut estimé, par calculs de balance et de transport de masse, que l'échantillonnage effectué en saison par la Direction de la qualité des eaux compte pour 0,001% du dinosèbe total appliqué sur deux des champs étudiés.

INTRODUCTION

For several years the Water Quality Branch, Atlantic Region, has investigated the presence of toxic organic substances in surface water and bottom sediment throughout the Atlantic Region. In recent years, the Branch has monitored in-use pesticides, utilized by agriculture in the region.

There are two principal environmental impacts that have been associated with agriculture: the first is elevated levels of nutrients in surface waters draining agricultural fields, and the second is chemical contamination due to pesticide usage (Maine Soil and Water Conservation Commission, 1977). Lee and Nielsen (1987) have expressed concern that up to 53.8 million people in the United States could be affected by agricultural chemical contamination of groundwater by either nitrates and/or pesticides. Concern for surface water quality has lead the Water Quality Branch to undertake toxic chemical surveys centering on regional in-use biocides (Clair et al. 1986 and 1987).

Pesticides may reach ground and surface waters via several pathways, including: surface runoff, erosion, leaching, spray drift, improper disposal of containers, and accidental spills. There have been reported cases of fish kills in the State of Maine as a result of: guthion being washed off a field with a heavy rain (runoff), premerge weed killer observed in Everett Brook due to a leaky valve at the mixing site (accidental), and guthion container leachate in Whitney Brook (improper disposal). In an instance where pesticide containers were crushed and buried in 1975, it was found that in 1977, endosulphan, dinoseb, and guthion were moving into ground water from the disposal site (Maine Soil and Water Conservation Commission, 1977).

Once an applied pesticide reaches the soil matrix it may be affected by various chemical, biological and physical processes. It may undergo photo-decomposition, degradation and metabolization by plant and bacteria, volatilization and runoff from the surface or absorption, chemical decomposition, biological degradation, capillary flow and leaching from the unsaturated layer of soil (Gillis et al., 1986). When pesticides reach the saturated zone, they can be transported via the processes of advection and dispersion, may undergo adsorption, partitioning ion exchange, or may undergo chemical or biological transformation to substances that may be more or less hazardous than the parent compound (Mackay et al., 1985). The principal reactions that occur in the saturated zones are hydrolysis and oxidation. Biotransformation can take place with the rate dependant upon pH, temperature, number and types of species of organisms, the concentration of the substance and the presence of microbial toxicants and nutrients (Mackay et al., 1985).

Clair et al. (1986 and 1987) implied that dilution by a receiving stream made the detection and quantitation of in-use pesticides difficult. To better determine the direct inputs from agriculture, the monitoring of a small sub-basin or point source was indicated. For this reason, the Water Quality Branch - Atlantic Region in co-operation with the Agriculture Canada, and the New Brunswick Department of Agriculture, undertook an investigation of agricultural runoff associated with subsurface drainage systems. The study afforded the opportunity to investigate the fate of in-use pesticides on tile drained potato fields, the quantitation of effluent flows, precipitation amounts, and application rates of pesticides, all the while providing a point source for sample collection.

Hill (1976) defined agricultural land drainage as the removal of excess water from soil by various means in order to

make the drained land more suitable for agricultural purposes. Drainage can be accomplished by use of ditches, drainage canals and channeling natural water courses. The type of land drainage encountered in this study was subsurface tile drainage which is a more delicate control form than the aforementioned methods.

The advantages of subsurface drainage to farmers in the Atlantic region are numerous. They include: earlier drying and warming of soil in the spring, removal of excess water from the root zone thus allowing a continuous supply of oxygen, deeper root penetration, better soil structure with less compaction, a decrease in surface runoff and erosion, less winter soil heaving, increased productivity and a wider range of crop choices (ACAE 1986).

Agricultural land drainage has been shown to be environmentally impactive when it is used to drain natural wetlands, where changes in vegetation, wildlife and water table may be drastic. Subsurface drainage may also cause environmental effects by changing the soil hydrology, sediment load of runoff, water chemistry and aquatic biology (Hill, 1976). Malecki et al. (1987) reported that land drainage has a direct effect on the farm economy by improving crop yields and areas under cultivation, while at the same time cautioning as to impacts upon natural wetlands.

Of primary interest to the Water Quality Branch is the effect of tile drainage on the transport of agricultural chemicals and pesticides from an application site to any receiving aquatic environment. The concern is that subsurface drainage may expediate transport and provide a point source of contaminants that could threaten an aquatic ecosystem or shallow groundwater aquifers, into which effluent flows. Effluent from subsurface drainage can also indicate the water quality of leachate leaving the rootzone and percolating to

deeper levels. It was intended that the use of tile drainage systems would provide a point source for sample collection, eliminate the detection limit observations due to dilution of past studies, and provide an indication of the potential impact of tile drainage on a receiving water body. With roughly 50,000 ha of agricultural land in the potato belt of New Brunswick in potato production, this study afforded the opportunity to gauge the impact of water movement into the unsaturated zone and eventually the water table.

METHODOLOGY

Project Scope

The subsurface drainage project was a federal-provincial cooperative effort initiated principally by Agriculture Canada to investigate the loss of nutrients from potato fields. Results of the Agriculture Canada aspect of the project will be of economic importance to the farmers who expend capital to fertilize fields. In order to accurately calculate nutrient export from the fields, flumes were installed by Agriculture Canada and the New Brunswick Department of Agriculture (NBDA) to monitor and record tile flow from each study field.

The Water Quality Branch of Environment Canada was invited to participate in the project with a role to investigate in-use pesticides and their presence in tile drainage effluent. Branch activities entailed close cooperation between the provincial and federal departments of Agriculture, and frequent contact with lay contract collectors. The Water Quality Branch used the services of NBDA lay collectors to sample the study fields on a predetermined schedule. Branch staff also sampled the fields in the spring and during the growing season. The Water Quality Branch Analytical Services Division performed the analysis of water samples for the pesticides of interest and also conducted major ion and nutrient analysis to characterize the effluent and to provide a quality assurance function for the Agriculture Canada laboratory.

Site Descriptions

The fields that were investigated consisted of tile drained areas ranging from 3.0 hectares to 10.4 hectares. The soil on all the study fields are typically rocky and of low organic content. The tile itself was perforated PVC

agricultural drainage tubing, 10 cm or 15 cm in diameter, that is similar to drainage tile used in the home construction industry. The tile was installed at a depth of approximately 1 metre using either a drainage tile trencher or a trenchless drainage plow, and graded for gravitational flow.

Five farm fields were selected by Agriculture Canada, and N.B.D.A. as being suitable for the purpose of the study. Criteria for selection were based upon the accuracy and extent of records of crop rotation, past pesticide and fertilizer usage, size of the tile drained field and projected field usage. Four sites were in the Grand Falls area while the fifth was near Florenceville. Figures 1 through to 5 illustrate each study site while Table 1 gives the NAQUADAT station number and description of each of the five study sites. Each field was identified by a letter, and will be cited by the designations "B, O, P, R, and S".

Two site outlets, R and P, were 75 metres from intermittent streams resulting in significant overland flow, and two, B and O, drained into low areas only. The last site, Figure 5, was most interesting in that a small spring fed pond at the outlet supported biological activity making it suitable for population studies. The outlet at site S was observed to have continuous flow throughout the study period indicating that the tile system was subject to ground water infusion. Located about 25 meters south-west of the pond was a second dugout pond that had been used as a disposal site for pesticide containers. Fifteen containers could clearly be seen under heavy aquatic growth. Along the southwesterly border of the field were found in excess of 20 discarded dinoseb containers that had been disposed of on the elevated rock border between the fields. These containers had clearly been punctured, indicating current triple rinse and puncture disposal practices. These discoveries while reconnoitering

the site provided additional impetus for the dinoseb aspect of the study that was to follow.

The New Brunswick Department of Agriculture conducted a detailed survey to determine past and proposed crop and pesticide usage. The 1982 to 1986 crop production histories, with the types and frequencies of pesticide applications and the 1987 and 1988 crop production plans with tentative pesticide schedules were obtained. Table 2 summarizes the anticipated 1987 crop production plans and the pesticide frequency derived from 1986 growing season information.

Parameter Selection

In order to formulate the 1987 Water Quality Branch sampling and analytical protocol, it was necessary to utilize the 1986 pesticide application data as a guide and design the project with enough flexibility so that target chemicals could be modified to suit actual in-use patterns. A review of the Analytical Services Division methodologies indicated that the Water Quality Branch had access to analytical methods for six of the pesticides used during 1986. These included dinoseb, metribuzin, MCPA, chlorothalonil, fenvalerate, and deltamethrin. The available analytical resources were concentrated on a minimum number of fields and pesticides to generate the greatest amount of data. The six pesticides were prioritized so that analytical resources could be effectively allocated. Dinoseb, metribuzin and chlorothalonil were selected as the pesticides of principal interest.

Recent evidence indicates that pesticides are being observed in ground water as a result of agricultural practices. Gillis et al. (1986) cited the triazine herbicide atrazine and the dinitrophenol, dinoseb as having been observed in groundwater in North America. Both have been observed in New Brunswick and Prince Edward Island and for

this reason have been placed on the Water Planning and Management Branch (WPMB) priority list, (Gillis et al., 1986).

Dinoseb has undergone recent review by Agriculture Canada and its use has been limited to that of a top kill agent. Its use in the amine form, as a pre-emergent herbicide was permitted only to those farms which had stocks to deplete. Zitko et al. (1976) has reported a 96 hour LC_{50} of 0.11 mg/L dinoseb for speckled trout (Salvelinus fontinalis) while Call et al. (1984) have reported a 24, 48, 96 and 192 hour LC_{50} of 0.8, 0.7, 0.7 and 0.5 mg/L for fathead minnows (Pimephales promelas). Dinoseb has also been responsible for fish kills in Scotland (Call et al. 1984) and in Godin Brook, New Brunswick (Zitko et al. 1976). The latter case in Godin Brook is an excellent example of improper sprayer filling and rinsing as the observations of dinoseb were 300 metres below where a sprayer was being rinsed and filled. Levels were confirmed at 4.81 mg/L by gas chromatography/mass spectrometry, Zitko et al. (1976). Call et al. (1984), estimated a "no effect" level for early life stages of fathead minnows of 14.5 to 48.5 μ g/L for dinoseb and expressed concern for stream loading in excess of 48 μ g/L.

Various authors, Kenaga et al. (1980) and McCall et al. (1980) have reported that soil sorption coefficients (K_{oc}) may be used to obtain estimates of potential for movement of pesticides in a soil matrix. Both Kenaga (1980) and Cohen et al. (1984) have reported a K_{oc} for dinoseb of 124 which places dinoseb in the "high" mobility classification used by McCall et al. (1980).

Atrazine, another Water Planning and Management Branch priority pollutant, had not been used on the study fields in the past and for that reason was not included in the analysis protocol. Metribuzin, however had been used on the fields and has been reported in the literature as having been observed in

tile drainage effluent. Muir (1976) observed concentration ranges from less than detection limit to 1.65 ug/L of metribuzin in tile drain water representing less than 1% of the total metribuzin applied. Metribuzin is soluble in water and does not adsorb significantly into soils. Kerpin (1980) indicated that under experimental conditions, 2% to 19% of a metribuzin solution was adsorbed by a soil matrix and that greater than 70% could be desorbed with water rinsings. The metribuzin that is adsorbed is influenced mainly by the quality of organic and mineral colloids present in the soil matrix (Filep et al. 1980).

Chlorothalonil has also been observed in tile drainage effluent by Krawchuck (Manuscript report), who reported 8 occasions when levels were between 0.06 ug/L and 3.66 ug/L. Chlorothalonil is a heavily used fungicide for which little data exist for aquatic inputs and effects. As both mancozeb and chlorothalonil are used extensively in the region it was determined worthwhile to try to address at least one of the in-use fungicides. The absence of documented method precluded the quantitation of mancozeb.

The three remaining pesticides on the initial list, MCPA, deltamethrin and fenvalerate, were to be investigated to a lesser extent by the Branch due to the rapid breakdown of the pyrethroids and the sporadic use of MCPA. The pesticides of interest, their chemical and trade names and the NAQUADAT parameter codes are listed in Table 3.

Major ion, nutrient and metal parameters, Table 4, were also included in the analytical protocol to describe and characterize the tile effluent and to provide a quality assurance function with the Agriculture Canada laboratory who were primarily interested in nutrients. Nutrient data was to be used to estimate the loading to receiving water courses

from tile drainage systems, and to indicate what changes might occur in tile effluent after the application of fertilizers.

Sampling

Sample collection of the tile drainage outlets was carried out by contract collectors hired by NBDA, with funds from the Canada/New Brunswick Agricultural Food Development Agreement, and augmented with sampling by personnel of the Water Quality Branch. The initial concept was for the Water Quality Branch staff to collect a set of spring run-off samples and reconnoiter the sites. Post rain event collection would be the responsibility of the contract collectors with supplemental collection by the Water Quality Branch. It was intended that: the spring run off samples would give background information and point out any carry over from the previous growing season, pre-application rain events would yield actual background levels, and post-application collection would elucidate any pesticide export in the tile drainage effluent. An end of season sample collection would again indicate the duration of observations and be useful for the following spring collection.

Precipitation observations from the previous five years, Table 4, indicated that ample precipitation could be expected in the Grand Falls area. An estimate of potential rain events (10-20 mm) that could trigger tile effluent flow was made and is also included in Table 5.

All samples collected throughout the study, were placed in coolers with cold packs and shipped on a next day basis to the Moncton laboratory. Where bottle types prohibited the use of coolers, cold packs were included in the shipping containers to keep the samples cool during transit. Upon arrival in Moncton the samples were placed in refrigerators and initialized on the data management system.

Analytical Procedure

All major ion, metal and nutrient analyses were carried out following the Water Quality Branch "Analytical Methods Manual 1979" (Environment Canada 1979). Dinoseb was determined by using in situ acetylation with acetic anhydride, extraction with petroleum ether, and quantitation on capillary column gas chromatography (CCGC) with electron capture detection. Metribuzin was determined using an XAD-Resin column to extract the target compound followed by elution with ethyl acetate and quantitation on packed column gas chromatography with a nitrogen-phosphorus detector. This was subsequently changed to capillary chromatography with a resultant lowering of the detection limit. Chlorothalonil was extracted using the method for organophosphorus insecticides and organochlorine insecticides whereby hexane was used as an extraction solvent and quantitation was by CCGC with electron capture detection. The extraction methodology for the pyrethroids was obtained from the Environmental Protection Service (Julien et al. 1985) with in-house modification of columns and chromatographic conditions to suit Water Quality Branch instrumentation. MCPA was quantitated using the BF_3 /methanol derivitization method for phenoxy acid herbicides as per the Analytical Methods Manual 1979 (Environment Canada 1979).

Quality Assurance/Quality Control

To ensure the validity of observations, a quality assurance/quality control aspect of the tile drainage project was implemented. This quality control program consisted firstly of Water Quality Branch staff instructing the contract collectors as to sample collection procedures, sample numbering and shipping instructions. The inclusion of random duplicates and triplicates was used to verify sample collection and quantitation. Spiked pesticide samples were

incorporated to verify recoveries from the sample matrix. As part of in-laboratory quality control, lab spikes and method blanks were routinely included to check laboratory extraction performance.

All pesticide observations that are positive were verified on at least one additional column of different polarity. And if observations were sufficiently high, every attempt to obtain a gas-chromatograph/mass spectrometer confirmation from an outside institution was taken.

The Water Quality Branch Analytical Services Division partakes of several quality control programs and audits of intra-laboratory and inter-laboratory nature for the determination of pesticides, major ions, metals and nutrients (Brun 1986, 1987). This continual monitoring of analytical performance ensures the accuracy, precision, and validity of data.

RESULTS AND DISCUSSION

1987 Observations

Past meteorological data (Table 5) implied that ample precipitation could be expected throughout the growing season, and that there should have been several rain events that would trigger tile outflow. This was not the case as rain was minimal and infrequent in the early part of the season resulting in very dry soil conditions and sporadic flow. These dry conditions inhibited any precipitation from reaching the tiles due to uptake by the soil matrix or, if the downpour was too fast, resulted in surface runoff. Figures 6 to 10 present Agriculture Canada hydrographs for each field. It can clearly be seen that there was limited rain until Julian date 260 (September 17). The hydrograph for site S clearly illustrates the effect of the groundwater infusion as there was virtually continuous flow throughout the study period. It was not until late in the season that there was significant precipitation to allow the collection of samples.

The economics of farming also became apparent as the season progressed with many farmers not using insecticides or changing at the last moment to other less costly products. The 1986 pesticide application data was useful as a planning tool for background spring collection but much of the 1987 sampling and quantitation had to be undertaken on an ad hoc basis with sample bottles being shipped from the Water Quality Branch only after consultation with N.B.D.A. staff in Florenceville. Even with this close contact, farmers would abandon or change their anticipated pesticide application at the last moment.

Of even more serious nature was an outbreak of bacterial ring rot in the potato crop cultivated at one of the study sites (S). This form of ring rot is extremely serious in

nature and resulted in the field being placed in quarantine. The collection of all project samples from that point, was left to Agriculture employees who were knowledgeable in outbreak management.

Table 6 presents the 1987 chemical application records for the five study fields as obtained by the New Brunswick Department of Agriculture. This actual application differed markedly from what was actually used in 1986 and what had been anticipated for 1987. The fungicides captan, mancozeb, and metalaxyl; the herbicides paraquat, diquat, and dinoseb; and the insecticide cypermethrin were the only biocides used in 1987 on any of the fields. Only dinoseb and cypermethrin were within the analytical expertise of the Branch Laboratory. The priority herbicide, dinoseb, was used both as a pre-emergent and a top kill agent thus allowing the Branch to concentrate on that particular chemical.

Major Ion, Nutrient and Metal Observations

Table 7 presents the major ion, nutrient and metal observations that were obtained during the 1987 study period. The first three and the fifth samples were collected from the pond at the tile outlet at Site S while the fourth sample was taken from the dugout disposal site, also at Site S. Major ion and nutrient data was obtained in order to characterize the tile effluent at each pesticide sampling. The majority of the samples were collected from sites O, R and S. Site P was in sparse winter rye from the previous season and did not receive any fertilizer or pesticides in 1987 while site B was in timothy clover and hay and received only lime on October 30th, 1987.

Early in the sampling season, it became apparent that special identification of tile drainage samples upon receipt by the Analytical Services Division was necessary. The

concentration of nitrate and total nitrogen was in excess of the routine operational range of the analytical techniques, resulting in the need to dilute the samples prior to analysis. These levels of nitrate in particular were troublesome when quantitating sulphate by ion chromatograph due to masking by nitrate (Komadina, personal communication).

Sites O, R, and S were all actively farmed with fertilizer applications at planting at rates of 1.1, 1.0 and 1.1 T/ha respectively. This fertilizer application was reflected by the levels of nitrate observed in the tile effluent from the three sites. The highest nitrate levels were observed at site R where the season's mean was 59 mg/L followed by site O at 22.5 mg/L and site S at 18.5 mg/L. Site P reported four observations of 26.0 mg/L nitrate on September 22, 1987 that illustrates the carry-over from 1986. The effluent flow from site R and P tended to be slightly acidic while that from O, S and B was more basic. This is also apparent in the alkalinities where sites O, S and B had higher alkalinities than R and P. Sites R and P also illustrated markedly higher chloride values as well. The levels of phosphorus were all at levels that would be considered acceptable for flow into lakes (McNeely et al. 1979), and represent soil absorption.

Site S is interesting in that the pond at the tile outlet when sampled in May and July under dry conditions, displayed sodium to potassium, and alkalinity to calcium ratios that are similar to ground water samples collected as part of the New Brunswick drinking water program. An old pesticide disposal site approximately 25 metres from the pond had similar major ion characteristics to the pond on the May 26th. As both of these sample collections were taken during dry periods of no flow they illustrate the importance the water table and aquifer play at this site. A major rain event resulted in tile flow on June 28th at site S and was characterized by

calcium being greater than alkalinity, potassium being greater than sodium, and an increase in nitrate and total nitrogen. Yet on July 28th the pond at the tile outlet had returned to a somewhat pre-event condition. It is hypothesized that the groundwater input to the pond dominates during dry periods and recharges the pond after a rain event has triggered tile flow. The tile effluent in all likelihood dramatically alters the chemistry of the pond with respect to calcium, alkalinity, potassium and nitrate for periods of time dependent on tile flow duration, and pond recharge rate from ground sources. Unfortunately, there were no samples collected from the tile outlet, pond, and disposal site at the same time to better describe the hydrology and water chemistry. The major ion concentrations from July 28th at the pond are slightly higher than those in May due likely to either input from the tile system or deep percolation past the tile to the water table.

Site R displayed the highest average nitrate observations of all study sites. This site, and site P also had a large difference between nitrate-nitrogen and total-nitrogen. At all other sites there was good agreement between $\text{NO}_3\text{-N}$ and total-N. The effluent from R and P was characterized as being slightly acidic, and having the highest potassium to sodium ratios. Calcium was often an order of magnitude in excess of alkalinity whereas all other outflows displayed calcium greater than alkalinity but of the same order of magnitude. Sites O and S displayed good agreement between $\text{NO}_3\text{-N}$ and total-N, were generally basic, had potassium to sodium ratios less than those of P and R, and had better agreement between calcium and alkalinity.

Site B which had not received any fertilizers displayed nitrate levels at the start of the season that were an order of magnitude below those of the other sites and diminished to less than 1.0 mg/L by November 5th. Alkalinity was greater

than calcium which is typical for ground waters in New Brunswick. Other anions and cations were also lowest at B.

Of note also, is that at sites R and S, where fertilizer had been applied May 18-20, there was a change in the water chemistry of the tile effluent from the samplings of June 17th to those of June 28th-30th. This change is manifested in the ratio reversal of calcium and alkalinity, the amounts of potassium, and the levels of nitrate. The samples of June 17 were as a result of a minor rain event whereas the samples collected from June 28-30 represent a major rain event that triggered tile flow for three days and was responsible for the transport of soluble species.

It is characteristic for subsurface drainage to have high levels of nitrate-nitrogen and chloride, and for surface runoff to have high levels of ammonia-nitrogen and phosphorus (Overcash et al. 1980). Smith et al. (1975) reported levels of nitrate as high as 99 mg/L in tile effluent from a study site in Illinois. Their data indicated that nitrate content had little correlation to times of application but correlated well with the quantities of flow from the tile drains implying that nitrates are stored and carried down through the soil column by precipitation. The greater the amount of water movement the greater the total nitrate carried from the surface soil. This most likely explains the levels of nitrates observed at site P where fertilizers had been applied in 1986 but not 1987. Site B which had been in clover in 1986 and 1987 did not display carry over nitrate.

Of concern to the Water Quality Branch are the high levels of nitrate that could reach a receiving body. Due to the low levels of carbon and phosphorus, they become the limiting nutrients in the tile effluent. Where the tile effluent could enter a shallow aquifer there is also potential for ground water contamination. The levels of nitrate

reaching a stream or groundwater would be affected by the amount of fertilizer applied, soil type, and the amount of precipitation. It has yet to be determined how quickly the receiving pond at site S returns to a pre-event status and what effect a sudden change in the water chemistry has on the resident biological population.

Metal observations are not as numerous as those for major ions and nutrients, as only 17% of the tile samples were quantitated for metals. This is as a result of various factors including, logistical and operational factors, and analytical resource allocation. Cadmium, copper, lead, iron and zinc observations were under the guidelines for the protection of freshwater aquatic life as established by McNeely (1979) and CCREM (1987). Some of the aluminum values were over the 0.10 mg/L limit with the highest observation being observed at Site P. It is felt that the soil composition is responsible for the aluminum and represents the norm for the individual sites.

Pesticide Observations

Pesticide observations for 1987 are presented in Table 8. The first sample was collected from the pond at the outlet for Site S while the second sample is a spike of the pond water on the same date. The remaining samples have been sorted by site and date.

Pesticide observations indicated that there was carry over of dinoseb from the 1986 growing season as it was observed on 3 fields (P,R,S) in the spring sample collection of April 7th and 8th, 1987. Dinoseb had been used as a top killer at two sites, P and S, in late August and early September of 1986 and had been used as a pre-emergent herbicide at site R in May of 1986. The elapsed time from application to sample collection was 7 months for sites P and

S and 11 months for site R. Site P had the highest levels of dinoseb in the spring samples with observations reported at 1.1 ug/L and 0.83 ug/L while site S reported levels of 0.17 ug/L and 0.20 ug/L for the 7th and 8th of April. Site R, with the longest application to collection date, had the lowest levels of 0.11 ug/L and 0.14 ug/L. Subsequent samples from site R on 4 occasions on June 28th were all less than the detection limit of 0.02 ug/L. Follow up samples (4) from site S on the 17th of June also indicated the absence of dinoseb with reported values of less than 0.02 ug/L. No follow up samples were collected at site P until late in the growing season.

The farmer at site S used dinoseb (DYTOP) as a pre-emergent herbicide on June 8, 1987. Four samples from a rain event on June 17 did not indicate the presence of dinoseb but five sequential observations on June 28th and 29th indicated levels of dinoseb ranging from 0.06 ug/L to 0.57 ug/L. This indicates a transport time within the soil matrix and is consistent with major ion and nutrient data from the same site, where it was shown that there was no shift in ion ratios until the rain events of June 28th to 30th. Samples from June 17th represent water that was already present in the unsaturated zone of the soil.

The farmer at site R at the last moment decided to use dinoseb as a top killer on September 4th providing the Branch an additional data source. A single sample collected on September 14 at site R indicated the presence of dinoseb at a level of 44.0 $\mu\text{g/L}$ in the tile effluent. Eight samples obtained on September 22nd and 23rd contained between 2.0 and 1.40 $\mu\text{g/L}$ of dinoseb and sixteen observations between October 4th and 6th were at levels ranging from 0.43 to 1.00 $\mu\text{g/L}$ on

the 4th, to 0.17 to 0.20 $\mu\text{g/L}$ on the 6th. A downward pattern was displayed in the concentrations between September 14th and the last sample on October 6th.

The highest observation of 44 $\mu\text{g/L}$ and five other subsequent samples were confirmed by gas chromatography mass spectrometry at the National Water Quality Laboratory, at CCIW, in Burlington, Ontario (Forbes, personal communication, 1988).

While the maximum observed level of 44 $\mu\text{g/L}$ is below the 96 hr LC_{50} values reported by Zitko et al. (1976) and Call et al. (1984) it is within the range reported by Woodward (1976), who determined a 96 hr LC_{50} to cutthroat (Salmo clarki) of 32 to 1400 $\mu\text{g/L}$ depending upon pH. The highest toxicity was reported at pH 6.5. It was also reported that yolk sac absorption and growth of lake trout fry (Salvelinus namaycush) was reduced in flow through tests at concentrations as low as 0.5 $\mu\text{g/L}$. Woodward (1976) also expressed that, based on his work, the maximum acceptable toxic concentration for predicting safe concentrations in the aquatic environment was below 0.5 $\mu\text{g/L}$ for dinoseb.

Twelve of the dinoseb observations from Site R exceeded the 0.5 $\mu\text{g/L}$ value determined by Woodward. Though the study sites do not flow directly into a stream they do illustrate that the levels of dinoseb could have some impact dependent on the dilution capability of a receiving water body.

No dinoseb was observed at either site O in the Grand Falls area or the control site B in Florenceville in the spring or subsequent samples. Site O had no dinoseb applied in 1985 or 1986 and site B was in red clover in 1986 and 1987.

The triazine herbicide metribuzin was the second pesticide on the Branch priority list for 1987. There was no

record of metribuzin usage at sites R, S and P dating back to 1982 while it had been used at site B in 1984 and site O in 1985. One of the spring samples from O indicated the presence of metribuzin at a level of $0.02 \mu\text{g/L}$ which is twice the detection limit and one sample from June 28 contained a detection limit value of $0.01 \mu\text{g/L}$. The remainder of the samples from June and September were all less than detection limit. At site B the two samples from the April collection and four samples from May 7th indicated the presence of metribuzin at the detection limit level of $0.01 \mu\text{g/L}$. These observations could indicate infusion of water from the upper undrained part of the field that had been under cultivation in the past. An improvement in the metribuzin detection limit occurred with a shift from packed column to capillary column with the thermionic specific detector. As a result the six samples collected in September indicated the presence of metribuzin at the new detection limit of $0.001 \mu\text{g/L}$. Using the quantitation techniques that were employed in the early part of the season would have resulted in observations reported as less than detection limit. As site R did not have any past history of metribuzin use it was selected as a control site and the four samples collected there on June 25th did not show any target compound. It would appear that there were either very low levels of residuals present in the soils of B and O or that there were unidentified physical processes at play during the spring snowmelt and subsequent runoff that would have involved the infusion of water from other adjacent fields into the tile systems.

The third priority chemical on the 1987 study sites was the fungicide chlorothalonil which as it turned out was not applied at any of the sites. On a purely random basis one site, O, was chosen for analysis of chlorothalonil residues. Of eight samples collected on September 14 and 15, 1987, 3 displayed levels of chlorothalonil ranging from 2 to 3 times detection limit. These values are suspect as they were

interspersed with values reported as less than the detection limit of $0.002 \mu\text{g/L}$. The tile outlet and calibration flume at site O is adjacent to a secondary chipseal road and could be affected by vehicular traffic. There is an adjoining field across the roadway belonging to another land owner. It is not inconceivable that there was some contamination of the flume by either spray drift from the adjoining field or by dust from the roadway. All other sampling sites were within protected wooded surroundings.

The synthetic pyrethroid cypermethrin was the only insecticide used on any of the five study fields. Cymbush 250 EC was applied at a rate of 0.15 L/ha on the 26th of July 1987 at site S. Eleven samples of tile effluent collected from August 3rd to 5th did not indicate any cypemethrin at a detection limit of $0.01 \mu\text{g/L}$. This is not surprising given that the pyrethroids as a group bind to soils and that cypermethrin has displayed negligible soil mobility (NRCC 1986). There is concern however for accidental overspray of water bodies and wetlands (NRCC 1986). Fenvalerate and deltamethrin were not used in the study area and as a result were eliminated from the analytical protocol. However, when cypermethrin was quantitated no spurious peaks were observed on the chromatograms that would indicate pyrethroid presence.

The last biocide identified by the Water Quality Branch was the chlorophenoxy herbicide MCPA. Chlorophenoxys have been used at some time on 4 of the study sites: 2,4-D at site R in 1984, MCPA at sites O and B in 1985, site P in 1983 and again at site O in 1986. Due to the reported mobility of 2,4-D it was intended to quantitate MCPA as it was cited on the 1987 crop production plans. However MCPA was not applied in 1987. As samples were being quantitated it became apparent that there was a matrix or solvent specific problem which prohibited the accurate quantitation of MCPA. MCPA, due to its lower molecular weight, elutes early after the solvent

front on the gas chromatograph. There were also coextractives that were in this early part of the chromatogram that were masking and interfering with MCPA. The Analytical Services Division is undertaking to address this problem and solve it for the 1988 sampling season.

Pesticide Transport

The presence of dinoseb in tile drainage effluent illustrates that parent compound was migrating through one metre of soil and being intercepted and removed by the tile system. Varying concentrations of dinoseb have been observed ranging from less than 0.02 to 44 $\mu\text{g/L}$. The high level observations are of concern due to the potential for a localized aquatic impact. However it is important on a mass balance basis to account for the total present in tile effluent as related to the total amount of dinoseb applied. In order to accurately describe the dinoseb mass balance, it would be necessary to quantitate the amounts of pesticide present in several compartments: spray drift, volatilization at application, surface runoff, soil adsorption, microbial degradation, chemical degradation, plant uptake, deep percolation and tile effluent. At best we can quantitate only the amount of pesticide present in the tile effluent, and delineate the observed levels and their environmental significance.

Yoo et al. (1981) reported that in a field investigation of the triazines cyanazine and procyazine, less than 0.01% of the herbicide losses were due to tile drainage removal. Muir and Barker (1976) reported parent and metabolite triazine losses in tile drainage in the vicinity of 0.15%.

Daily runoff data was obtained from Agriculture Canada, and was formatted by Water Quality Branch EDP personnel so as to be compatible with the RS1 data management package.

Conversion from mm/day to L/s was carried out so as to calculate pesticide export via the tile system. Though complete hydrographs were obtained, the pesticide samples collected represented only a few segments of any given hydrograph. In order to best describe the amount of dinoseb removed from site R and S the integrating techniques of Spencer et al. (1985) were used wherein the total pesticide losses were based on the average concentration and the total runoff for a given day. Where a single observation was recorded for a hydrograph a 24 hour output was used. Using this approach, Water Quality Branch observations accounted for 0.001% of the dinoseb at site R and less than 0.001% of the dinoseb at site S, as calculated by using the application rate, area of the field and amount of active ingredient.

In order to describe the worst case scenario, based on Branch data, the maximum observation recorded at site R and S was multiplied by the total volume of water that emanated from the respective outlets. This amount was again compared to the total applied and indicated that at site R, 0.3%, and at S, 0.03% of the dinoseb would be accounted for in tile effluent.

As site S was affected by groundwater infusion, site R most accurately reflects the tile-only export. Due to data gaps it is difficult to define with certainty the amount of dinoseb lost through the tile system, as a result of dinoseb removal by late autumn rains and spring snowmelt.

The total amount of dinoseb observed in the tile effluent was low as compared to the amount of active ingredient applied to each field. Overcash et al. (1980) report that pesticides in tile water are normally dilute and present primarily due to the low organic material content of the soil.

It would be concluded that the tile transport mechanism is accounting for only a small part of the total amount of

dinoseb applied. Spray drift, volatilization, surface runoff, deep percolation, biochemical degradation and chemical degradation appear to be of greater significance than tile effluent. As there are 50,000 ha of agricultural land in the upper Saint John River valley under potato cultivation, the implications of deep percolation to shallow aquifers, are significant. The use of a highly soluble biocide on tile systems warrants further investigation into the potential for localized biological stress to a receiving aquatic system. Though the total amount of pesticide emanating from the tiles may be low as compared to the net applied, it does represent an environmental input that may cause sub-lethal effects.

Biological Sampling Results

Where Site S was observed to have a small pond and an old disposal pond, it was felt worthwhile to investigate the resident phytoplankton and zooplankton populations. Biological samples were collected by Branch staff on May 14, 26 and July 28 from the pond at the outlet and from the disposal site on May 26. Population identification was carried out under a Pestfund contract. It was intended to collect a greater number of phytoplankton and zooplankton samples but the very dry conditions and ring rot out break curtailed sampling activities.

The sample from May 14th indicated various phytoplankton but no zooplankton, while the sample of May 26th displayed less diversity of phytoplankton and the presence of 5 zooplankton types. The sample of July 28th displayed a similar diversity but only 3 species from the previous collection. Navicula was the only phytoplankton cell that was seen in each of the three pond samples. The May 26th phytoplankton cells were pigmentless except for Cosmaria.

The one sample taken from the disposal pond containing old pesticide containers displayed very limited phytoplankton, 2 vegetative species of Spirogyra, and very rarely Navicula which was present in the other sites. There was also no zooplankton on May 26th at the disposal site.

Dinoseb had been applied on June 8th and was detected in the tile effluent on June 28th and 29th but was not detected in the pond on July 28th. Due to the limited biological samples collected it is impossible to identify a direct cause effect relationship but the few phyto- / zoo-plankton species detected does warrant further study. Unfortunately this site will be unaccessable and this investigation will not take place in 1988.

1987 Quality Assurance Results

In addition to standard laboratory quality assurance practices, duplicate samples were incorporated into the field collection of the samples. Four sets of duplicate and one set of triplicate samples for major ions were collected at random by the lay collectors representing 11% of the samples collected. There was good agreement on all parameters in the duplicates and triplicates. It was hoped to have the QA aspect account for 15% of the analysis but 2 sets were mislabelled as to collection time and could not be used with confidence.

Quality assurance for the toxic chemical analysis consisted of laboratory spikes, blanks, field spikes, and duplicates. Five sets of triplicate samples were used in the pesticide aspect of the study. There was good agreement within each set of triplicates. There were also 5 dinoseb spiked samples, that when quantitated gave 47.5%, 90%, 65%, 81%, and 73% recoveries of dinoseb. Dinoseb was spiked into field collected samples at a level an order of magnitude above

the detection limit of 0.02 $\mu\text{g/L}$ and in the operational ranges observed. Where actual levels were reported above this range the samples were diluted so as to be in the linear range for detector response. Two metribuzin spikes were reported as 100% and 120% recoveries. The triplicates and spiked samples accounted for 16% of the toxic chemical samples.

1987 CONCLUSIONS

The first year of this joint Federal-Provincial project has illustrated that federal and provincial departments can co-operate on a mutually beneficial project in an efficient manner. This close co-operation has resulted in a large amount of data being generated in various technical realms. The sharing of expertise is of benefit to all parties involved.

Thus far it has been shown that there has been carry over of the herbicide dinoseb from one growing season to the following season. The environmental implication of tile drainage in low organic soils is that the tile system will act as a transport mechanism intercepting downward moving residues. The levels of dinoseb that have been observed ranged from 44 $\mu\text{g/L}$ to less than 0.02 $\mu\text{g/L}$. The single observation of 44 $\mu\text{g/L}$ of dinoseb in tile effluent is in the high end of the range cited by Call et al. (1984) and might cause a localized biological effect in the immediate vicinity of the tile outlet. The extent of any effect would be dependent upon the size and dilution capability of any receiving water course, and the duration of the input level. The total amount of parent dinoseb removed by the tile system as calculated from Branch observations accounts for only 0.001% of the parent compound that was applied to the two sites.

Also of interest are the trace levels of metribuzin reported in the spring at Sites 0 and B. Further investigations are warranted to ascertain if these observations are as a result of residuals in the soil or due to migration from up-slope fields.

The levels of nitrate and total nitrogen leaving the fields is of importance to the farmer and indicates further

agricultural studies into fertilizer application rates and frequency. Impacts of nitrate loading would also be dependent upon the dilution capability of a receiving water body but does indicate potential problems for small systems and shallow aquifers.

Outlook for project Period April 88 to March 89

The observations recorded in 1987 have provided a starting point and indicator for project direction for 1988. Dinoseb should remain a priority chemical with these specific objectives: to ascertain if dinoseb will be observed at site P in the spring, in excess of a year and a half after the last known application, and to follow the presence of dinoseb at sites R and S where it was used and observed in 1987.

The 1987 chemical application records, Table 5, indicate that site B which has been in clover in 1986 and 1987 and received only lime in the fall of 1987, will be placed into potato production in 1988. This will allow the Branch to follow the changes in major ion chemistry and pesticide presence as the site changes in usage practice.

Site P may be in potatoes or winter rye while site S will be in grain or grass. Though no MCPA was used in 1987, these are the only two sites where the possibility of MCPA application exists.

The only insecticide application was that of Cymbush (cypermethrin) at site S. Though several insecticides are listed for use in the potato industry by the Atlantic Provinces Agriculture Services Co-ordinating Committee (1986) none was used, indicating that there were either no, or limited, pest infestations. The uncertainty associated with the type and magnitude of infestation and the economics of insecticide selection makes the planning and resource allocation for insecticide analysis a best guess proposal. As a result, insecticide analysis will have to proceed on an ad hoc basis by allocating analytical resources, with specific parameters to be assigned during the growing season.

Therefore it is recommended that for 1988 Branch involvement in the subsurface drainage project should center upon:

- 1) Follow-up on the dinoseb observations recorded at sites P, R, and S.
- 2) Should metribuzin or MCPA be used they should be investigated as they were on the initial prioritization listing, and MCPA is currently being re-evaluated by Agriculture Canada.
- 3) Site B should be monitored to determine the changes in production as related to major ion, nutrient and pesticide presence.
- 4) Site S should be monitored, if possible, to determine how quickly the effluent chemistry returns to a more typical nature.

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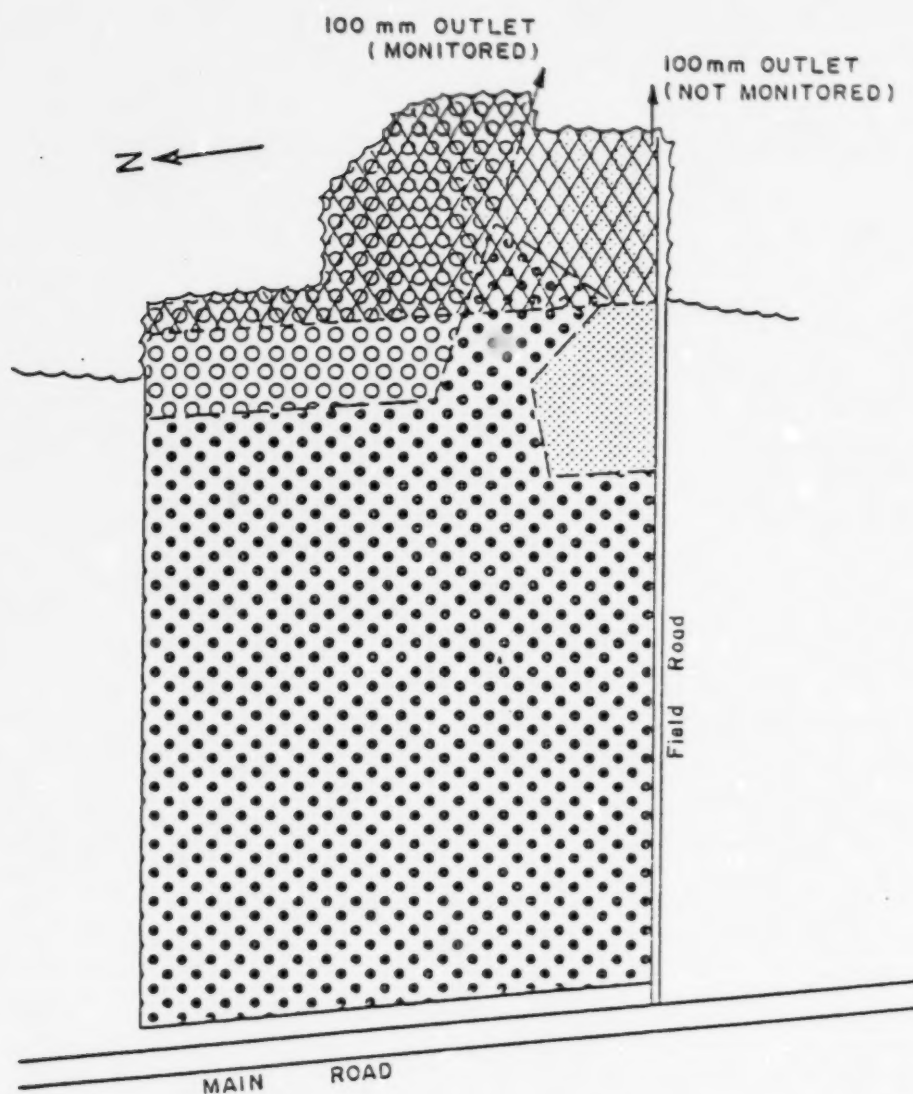
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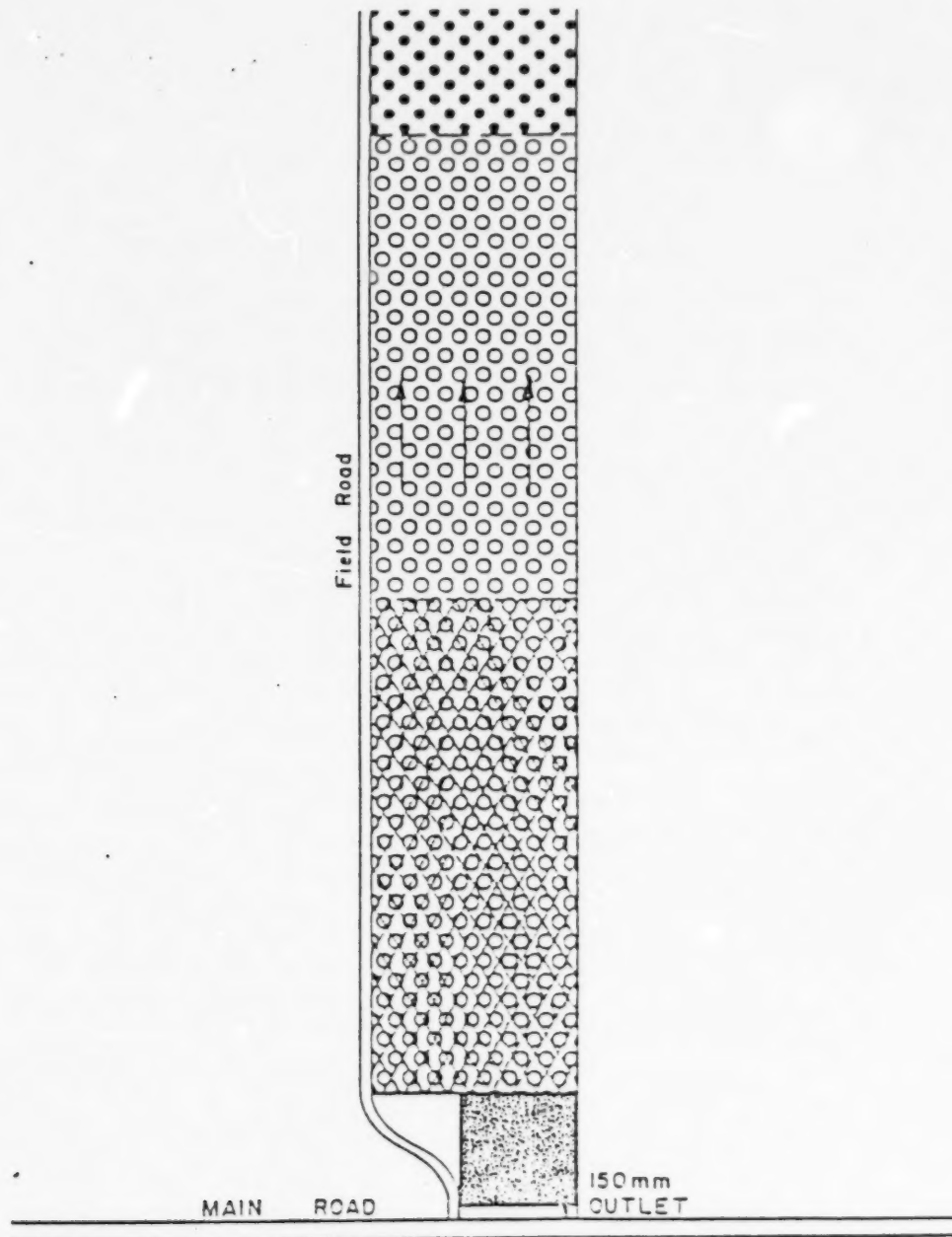
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- ooooo SUBDRAINED AREA, 3.1 ha (MONITORED)
- xxxxx SUBDRAINED AREA, 1.9 ha (NOT MONITORED)
- UNDRAINED AREA, 14.8 ha
- XXXXX USED ONLY FOR HAY PRIOR TO DRAINAGE, 3.3 ha
- ↑ ↑ 1986 ROW DIRECTION
- ~~~~~ WOODS
- SCALE 1:5000

FIGURE 1: SITE 'B' FIELD PLAN

40



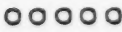
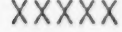
-  AREA NOT SEEDED IN 1987 0.6ha (BARLEY)
-  SUBDRAINED AREA , 10.4ha
-  UNDRAINED AREA , 3.2 ha
-  PASTURE PRIOR TO DRAINAGE , 6.0ha
-  1986 ROW DIRECTION
-  WOODS
- SCALE 1:5000

FIGURE 2: SITE 'O' FIELD PLAN

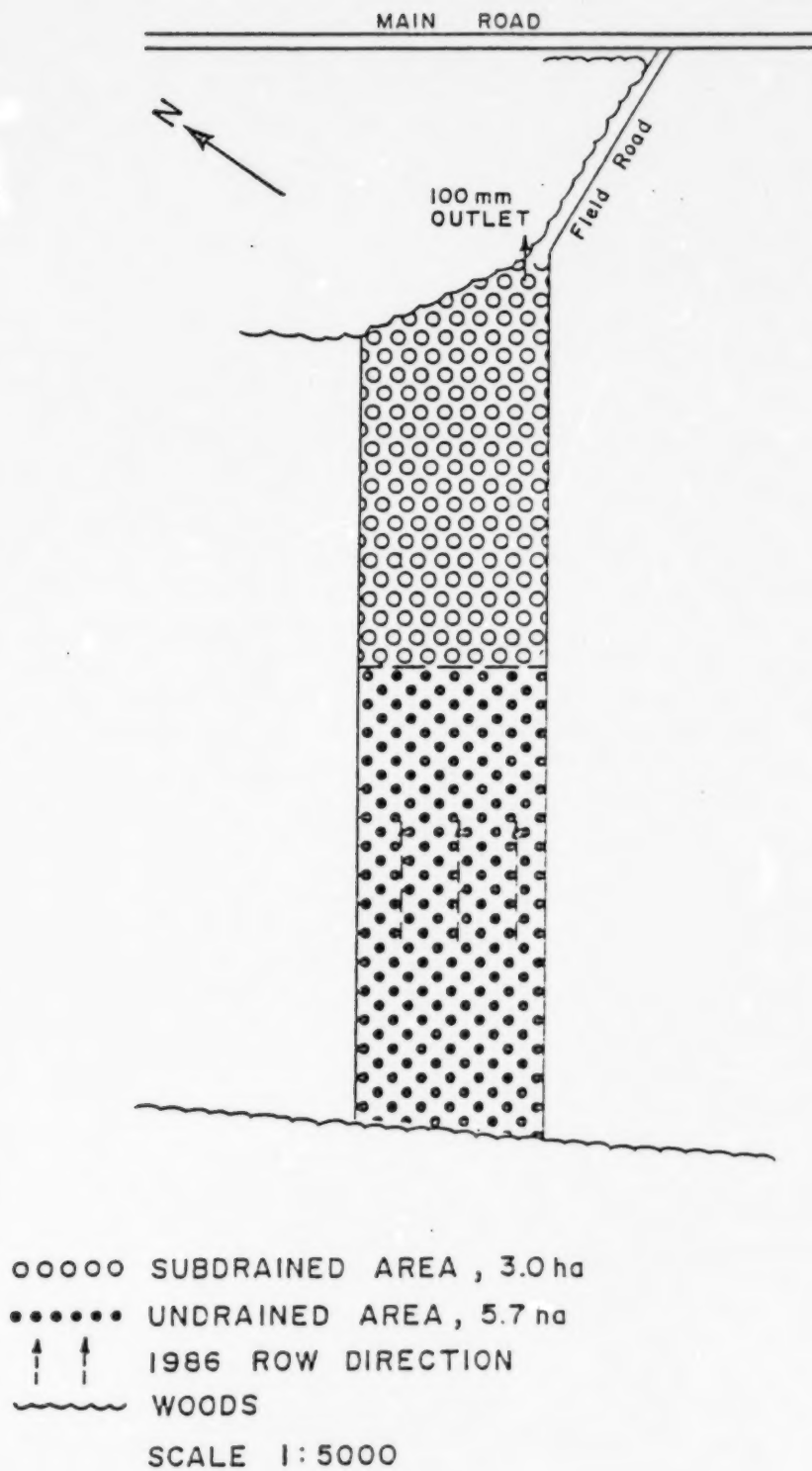
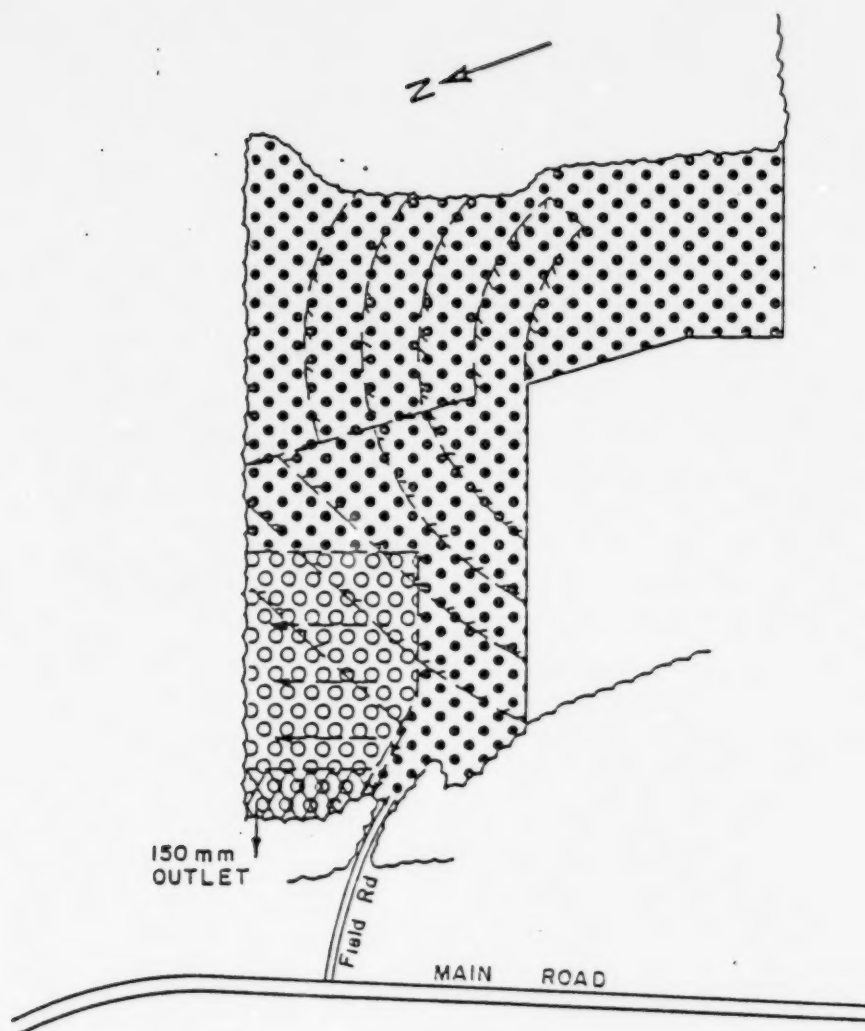


FIGURE 3: SITE 'P' FIELD PLAN



oooooo SUBDRAINED AREA, 7.7 ha

..... UNDRAINED AREA, 22.7 ha

XXXXXX: TO WET TO FARM 1982-83, 2.0 ha

--- DIVERSION TERRACE (CONSTRUCTED FALL, 1986)

↑ ↑ ROW DIRECTION PRIOR TO TERRACING

~~~~~ WOODS

SCALE 1:10,000

FIGURE 4: SITE 'R' FIELD PLAN

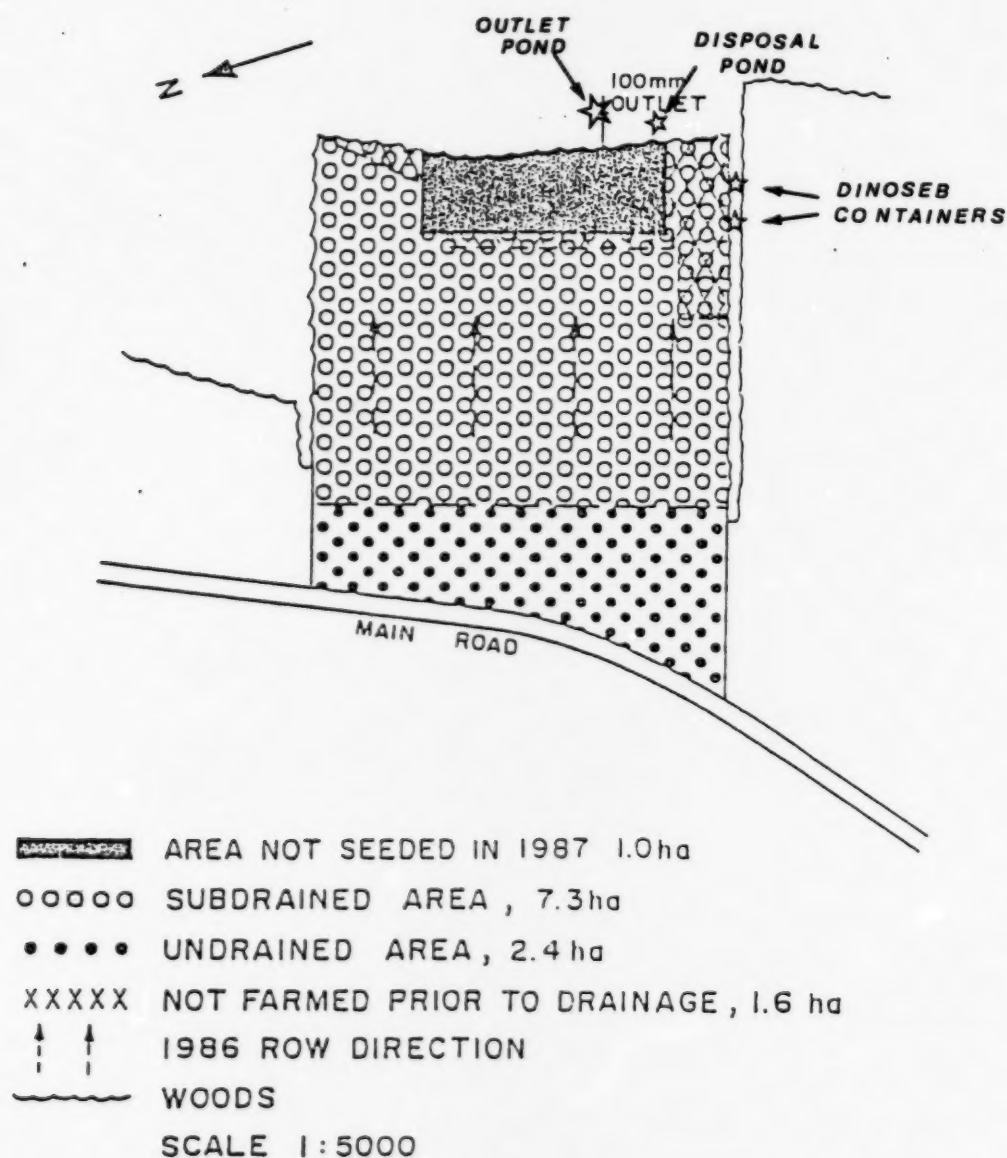


FIGURE 5: SITE 'S' FIELD PLAN

FIGURE 6: DISCHARGE FROM SITE B

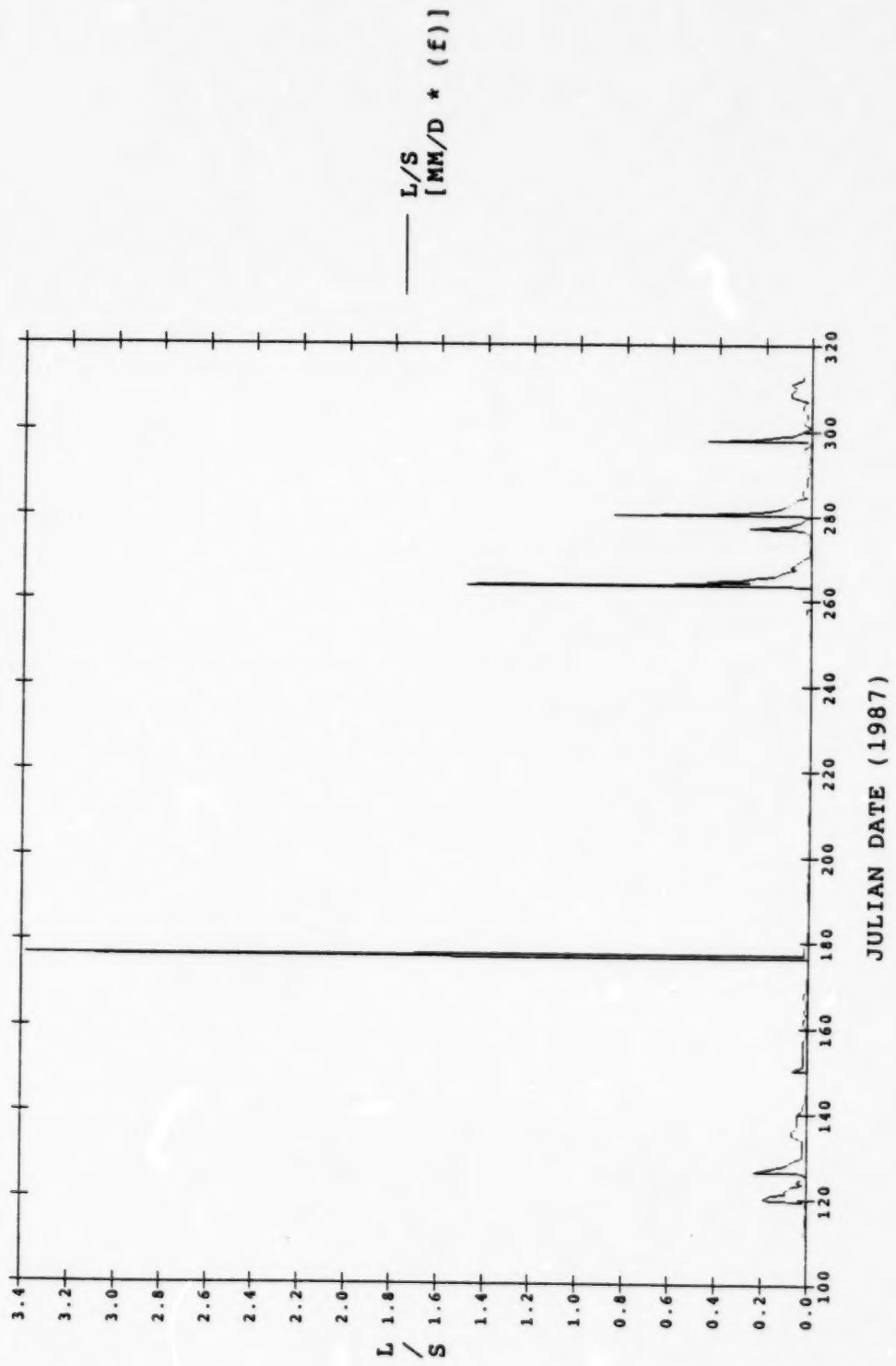


FIGURE 7: DISCHARGE FROM SITE O

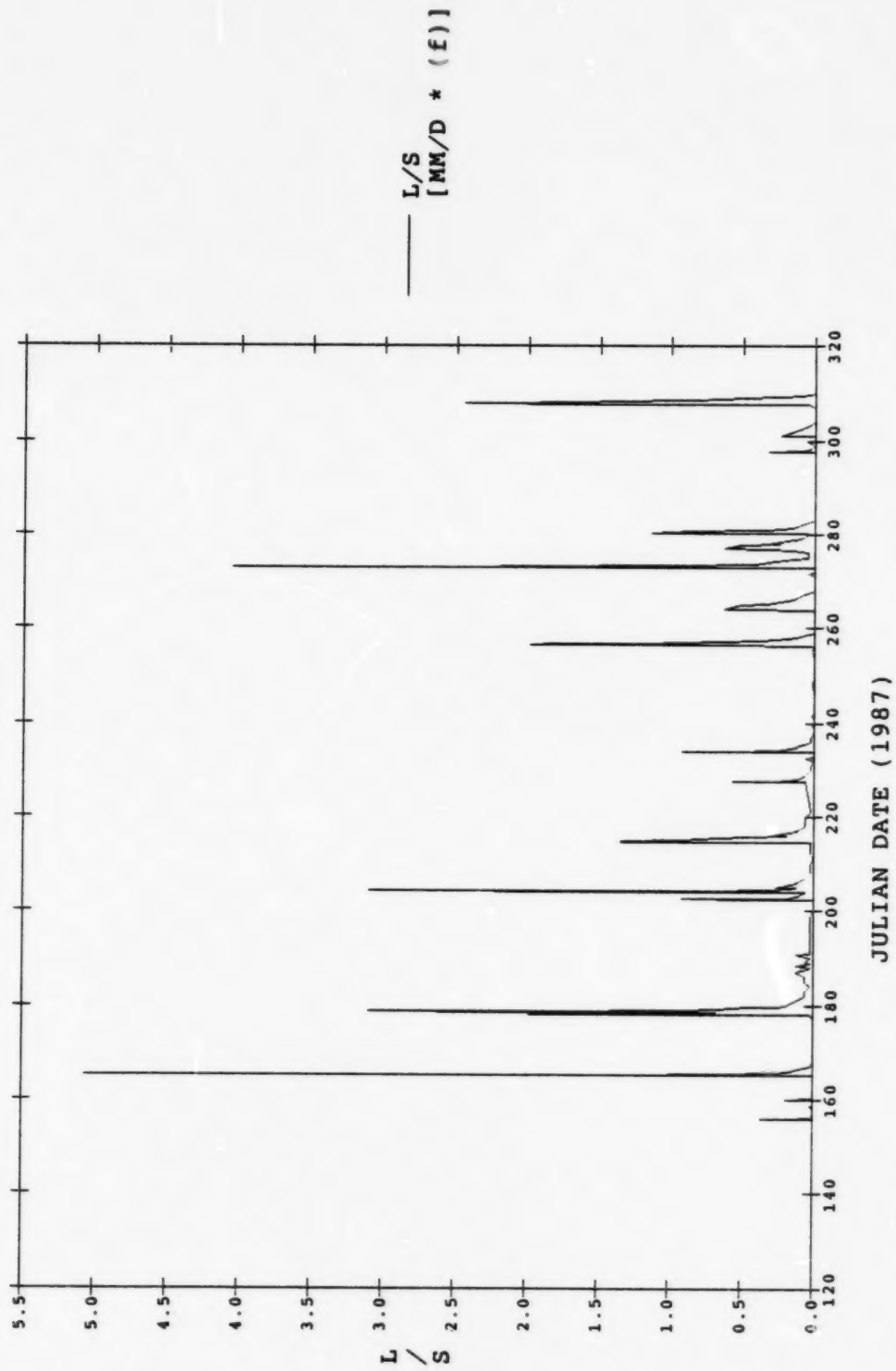


FIGURE 8: DISCHARGE FROM SITE P

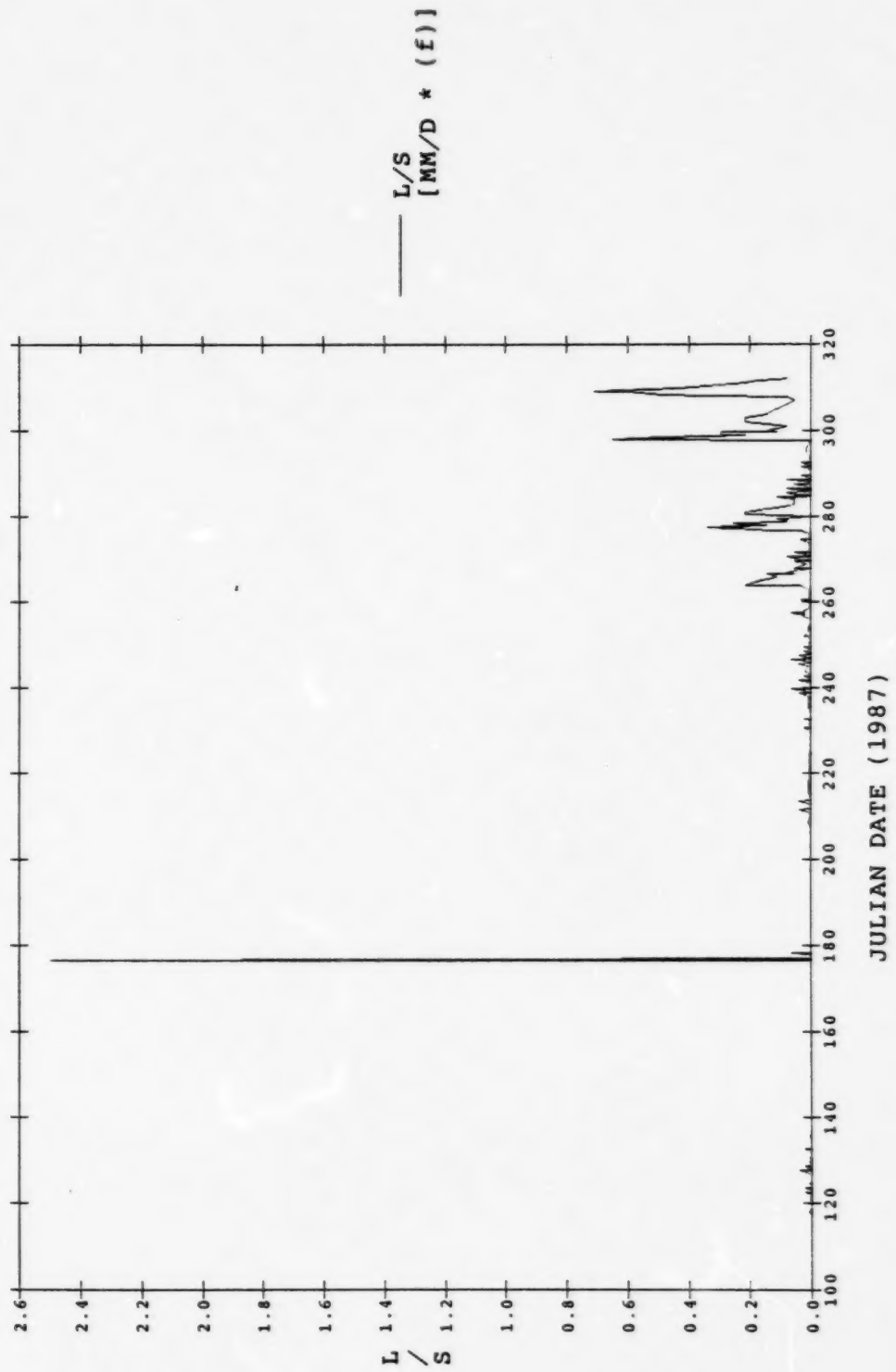


FIGURE 9: DISCHARGE FROM SITE R

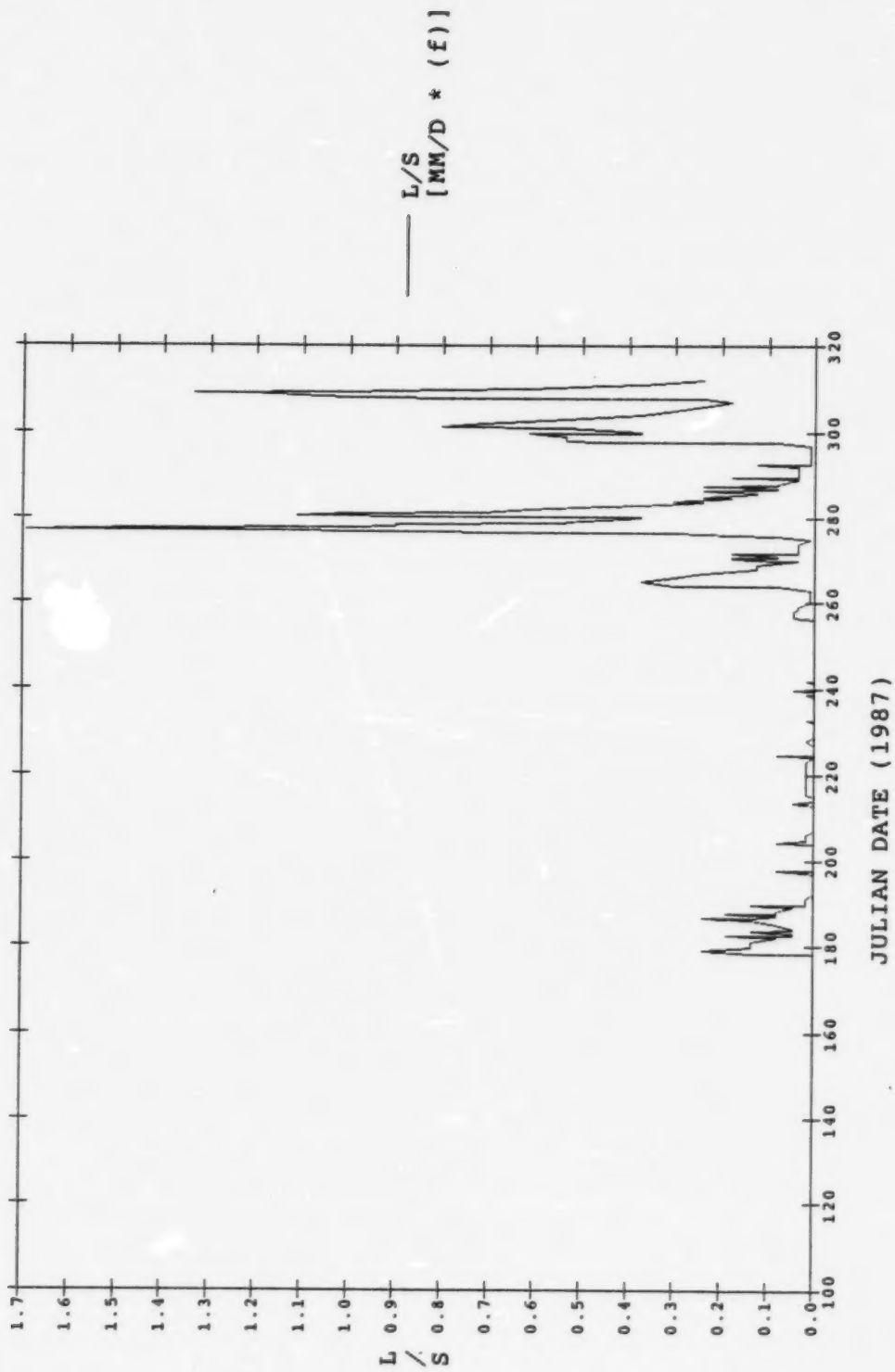


FIGURE 10: DISCHARGE FROM SITE S

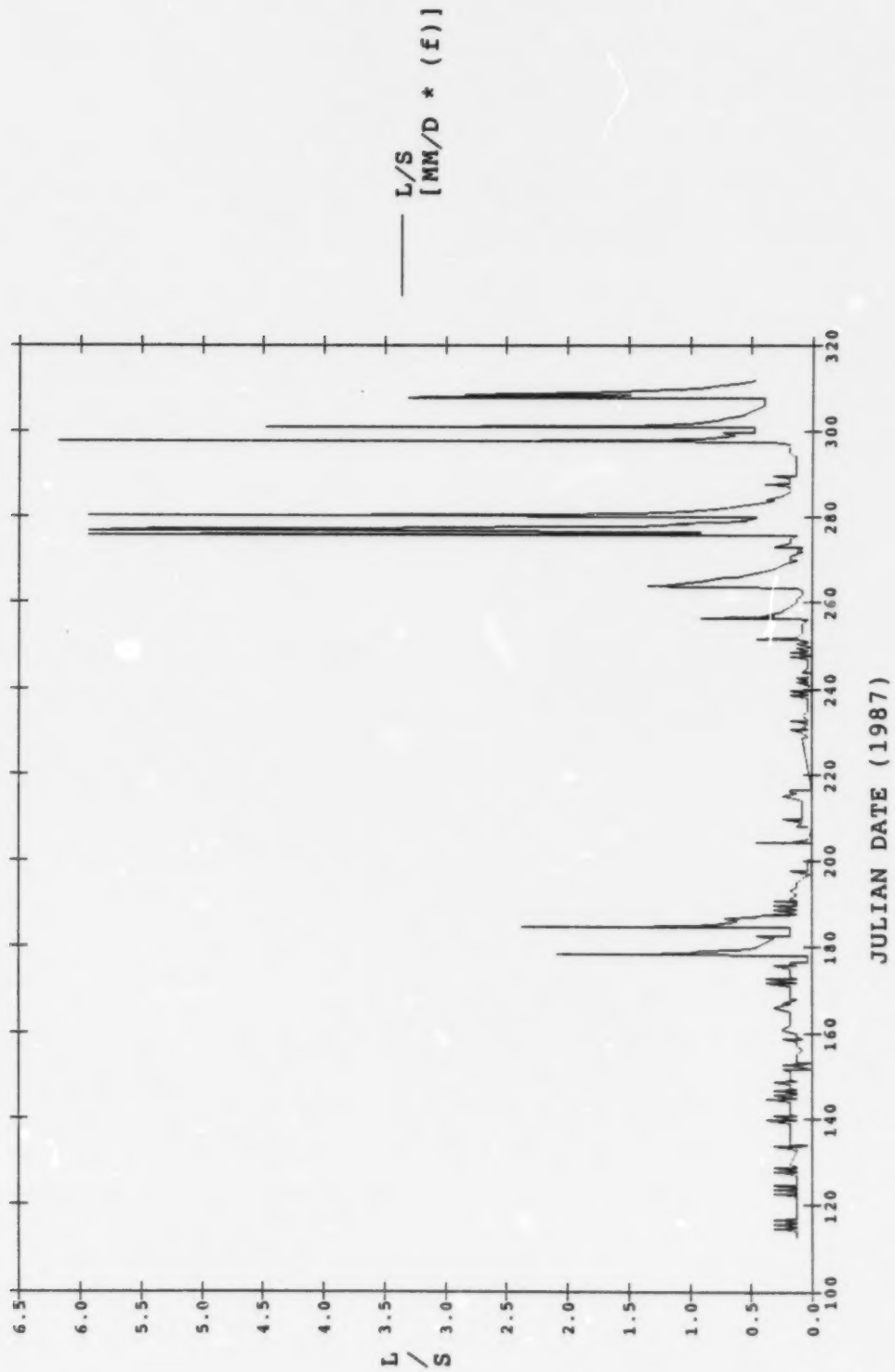


TABLE 1

NAQUADAT Station Number and  
Description of Study Sites

| NAQUADAT<br>Station Number | Site Description     | Site<br>Designation |
|----------------------------|----------------------|---------------------|
| 13NB01AF0001               | Tile Drainage Outlet | O                   |
| 13NB01AF0002               | Tile Drainage Outlet | R                   |
| 13NB01AF0003               | Tile Drainage Outlet | P                   |
| 13NB01AG0001               | Tile Drainage Outlet | S                   |
| 13NB01AJ0001               | Tile Drainage Outlet | B                   |

TABLE 2

Summary of Anticipated 1987 Crop Production Plans  
and Pesticide Application Frequency Based  
on 1986 Applications

| <u>Month</u> | <u>Site<br/>Crop</u> | R<br>Seed Potatoes               | S<br>50% Potatoe 50% grain                                                     |
|--------------|----------------------|----------------------------------|--------------------------------------------------------------------------------|
| May          |                      | 1 x Dinoseb<br>1 x Paraquat      | 1 x Dinoseb                                                                    |
| June         |                      |                                  | 1 x MCPA                                                                       |
| July         |                      | 2 x Mancozeb<br>1 x Deltamethrin | 3 x Chlorothalonil                                                             |
| August       |                      | 4 x Mancozeb                     | 5 x Chlorothalonil<br>1 x Fenvalerate                                          |
| September    |                      | 1 x Mancozeb<br>1 x Diquat       | 1 x Metalaxyl +<br>Mancozeb<br>1 x Chlorothalonil<br>1 x Diquat<br>1 x Dinoseb |

| <u>Month</u> | <u>Site<br/>Crop</u> | P<br>Seed Grain | O<br>Process Potatoes                   | B<br>Red Clover |
|--------------|----------------------|-----------------|-----------------------------------------|-----------------|
| May          |                      |                 | 1 x Metribuzin                          | No Pesticides   |
| June         |                      | 1 x MCPA        | 4 x Mancozeb                            | "               |
| July         |                      |                 | 4 x Mancozeb<br>1 x Sethoxydim + Assist | "               |
| August       |                      |                 | 4 x Mancozeb<br>2 x Metalaxyl           | "               |
| September    |                      |                 | 1 x Diquat                              | "               |

TABLE 3

**Pesticide of Interest, Chemical Name and  
NAQUADAT Parameter Code**

| <u>Pesticide</u>   | <u>Type</u> | <u>Chemical Name</u>                                                                   | <u>Parameter Code</u> |
|--------------------|-------------|----------------------------------------------------------------------------------------|-----------------------|
| Dinoseb            | (H)         | 2-sec-butyl-4,6-Dinitrophenol                                                          | 89825                 |
| MCPA               | (H)         | 4-chloro-2-methyl phenoxyacetic acid                                                   | 89410                 |
| Metribuzin         | (H)         | 4-amino-6-(1,1-dimethylethyl)-3-(Methythid)-1,2,4-triazin-5(4H)-One                    | 89820                 |
| Chlorothalonil (F) |             | Tetrachloroisophthalonitrile                                                           | 89985                 |
| Fenvalerate (I)    |             | Cyano (3-phenoxybenzyl) methyl 4-chloro-alpha (1-methyl ethyl) Benzeneacetate          | 89370                 |
| Deltamethrin (I)   |             | Cyano (3-phenoxybenzyl)-cis-3-(2,2-dibromovinyl)-2-2-dimethyl cyclopropane carboxylate | 89360                 |

NOTE: Type (H) Herbicide, (F) Fungicide, (I) Insecticide

TABLE 4

Major Ion, Nutrient and Metal Parameters  
with NAQUADAT Parameter Codes

|                          |       |
|--------------------------|-------|
| Color                    | 02011 |
| Calcium                  | 20110 |
| Alkalinity               | 10101 |
| Turbidity                | 02073 |
| Magnesium                | 12107 |
| Potassium                | 19103 |
| Sodium                   | 11103 |
| pH                       | 10301 |
| Chloride I.C.            | 17209 |
| Sulphate MTB             | 16304 |
| Sulphate IC              | 16309 |
| Silica                   | 14102 |
| Specific Conductance     | 02041 |
| Dissolved Organic Carbon | 06107 |
| Nitrate + Nitrite        | 07110 |
| Total Nitrogen           | 07601 |
| Total Phosphorus         | 15413 |
| Copper                   | 29305 |
| Lead                     | 82302 |
| Zinc                     | 30304 |
| Iron                     | 26304 |
| Manganese                | 25304 |
| Aluminum                 | 13305 |
| Cadmium                  | 48302 |
| Non-filterable Residue   | 10401 |

TABLE 5

**MONTHLY PRECIPITATION DATA  
GRAND FALLS, N. B.**

**TOTAL MONTHLY PRECIPITATION (Amirault 1987)  
in Millimeters**

|           | <u>1982</u> | <u>1983</u> | <u>1984</u> | <u>1985</u> | <u>1986</u> |
|-----------|-------------|-------------|-------------|-------------|-------------|
| May       | 11.8        | 133.0       | 172.0       | 103.0       | 60.0        |
| June      | 83.9        | 16.0        | 170.0       | 116.0       | 58.0        |
| July      | 127.5       | 162.0       | 134.7       | 204.0       | 113.0       |
| August    | 143.0       | 120.0       | 52.0        | 50.0        | 150.0       |
| September | 124.0       | 114.0       | 53.0        | 75.0        | 109.0       |
| October   | 46.0        | 50.0        | 51.0        | 40.0        | 53.0        |

**RAIN EVENTS THAT COULD POTENTIALLY  
TRIGGER TILE EFFLUENT FLOW**

|           | <u>1982</u> | <u>1983</u> | <u>1984</u> | <u>1985</u> | <u>1986</u> |
|-----------|-------------|-------------|-------------|-------------|-------------|
| May       | 3           | 5           | 5           | 4           | 2           |
| June      | 4           | 1           | 4           | 5           | 2           |
| July      | 3           | 7           | 6           | 7           | 4           |
| August    | 5           | 5           | 1           | 3           | 5           |
| September | 4           | 4           | 2           | 4           | 3           |
| October   | 3           | 2           | 3           | 1           | 3           |

TABLE 6

1987 CHEMICAL APPLICATION RECORDS (Gartley, 1987)SITE B

CROP: Timothy Clover Hay

1 - 14 July: Good yield of hay harvested (round bales)

October 30: 2.5 T/ha lime applied (broadcast)

Planned 1988 Crop: Processing/table potatoes

SITE O

CROP: Processing/Table Potatoes (russets)

20 May: Crop planted with 1.1 T/ha 15-10-15  
Fertilizer (banded), Seed was treated with captan

3 June: Applied 0.9 l/ha paraquat (Gramoxone 200 g/l) by  
ground sprayer

1 July: Applied 2.0 kg/ha mancozeb (Dithane M45) by airplane

8 July: Applied 2.0 kg/ha mancozeb by airplane

15 July: Applied 2.0 kg/ha mancozeb by airplane

22 July: Applied 2.0 kg/ha mancozeb by airplane

29 July: Applied 2.0 kg/ha mancozeb by airplane

5 August: Applied 2.0 kg/ha mancozeb by airplane

12 August: Applied 2.0 kg/ha mancozeb by airplane

19 August: Applied 2.0 kg/ha mancozeb by airplane

26 August: Applied 2.0 kg/ha mancozeb by airplane

2 September: Applied 2.0 kg/ha mancozeb by airplane

No insecticide was applied

No topkill was applied (frost)

5-11 October: Potatoes were harvested

N.B. Barley was seeded 20 May with 0.4T/ha 15-10-15 Fertilizer (banded) on 0.6 ha of the field near the main road and outlet. No other fertilizer or chemicals were applied. The barley was harvested during September.

Planned 1988 crop: Processing/table potatoes

#### SITE P

CROP: Fallow (sparse cover crop of winter rye planted fall, 1986)

23 July: Mowed rye crop left in field

11 August: Plowed 1/2 of field width

25 August: Plowed remainder of field

9 September: Seeded field to winter rye (160 kg/ha seed broadcast and harrowed-in)

No fertilizer or chemicals were applied

Planned 1988 Crop: Winter rye or potatoes

#### SITE R

CROP: Seed Potatoes (sebagos)

18-19 May: Crop planted with 1.0 T/ha 15-10-15 fertilizer (banded). Seed was treated with mancozeb and douglas fir bark (Tuber Seal)

8 June: Applied 2.5 l/ha paraquat (Gramoxone 200 g/l) by ground sprayer

10 July: Applied 2.0 kg/ha mancozeb (Dithane M45) by ground sprayer

22 July: Applied 2.0 kg/ha mancozeb (Dithane M45) by ground sprayer

28 July: Applied 5.6 l/ha seaweed extract (Sea Cure) by ground sprayer

5 August: Applied 2.0 kg/ha mancozeb (Dithane M45) by ground sprayer

18 August: Applied 2.0 kg/ha metalaxyl mancozeb (Ridomil MZ) by ground sprayer

4 September: Applied 1.5 kg/ha mancozeb (Dithane M45) and  
11 l/ha dinoseb (Dytop 300 g/l) by ground sprayer

16 September: Applied 1.1 l/ha diquat (Reglone 200 g/l) by  
ground sprayer

29 September: Crop was harvested

No insecticide was used

Planned 1988 Crop: Seed or table potatoes

#### SITE S

CROP: Seed Potatoes (Atlantic)

18-19 May: Crop planted with 1.1 T/ha 10-10-10 fertilizer  
(banded) No seed treatment

8 June: Applied 4.5 l/ha dinoseb (Dytop 300 g/l) by ground  
sprayer

17 July: Applied 2.0 kg/ha mancozeb (Manzate 200) by ground  
sprayer

24 July: Applied 2.0 kg/ha mancozeb by ground sprayer

26 July: Applied 0.15 l/ha cypermethrin (Cymbush 250 EC) by  
ground sprayer on N. half of field

6 August: Applied 2.0 kg/ha mancozeb by ground sprayer

12 August: Applied 2.0 kg/ha mancozeb by ground sprayer

28 August: Applied 4.5 l/ha diquat (Reglone) by ground sprayer

15-30 September: Harvested crop

Planned 1988 Crop: Grain or grass

N.B. Approximately 1.0 ha at the E. (bottom) side of the  
field near the outlet was left fallow

NOTE: The above information is based on farmer reports  
during the growing season.

Clair Gartley, P. Eng.

TABLE 7 MAJOR ION, NUTRIENT, AND METAL OBSERVATIONS IN 1987 REPORTED IN MG/L

|    | SITE     | SAMPLE | SDATE     | JULIAN<br>DATE | STIME | COLOR | CALCIUM | ALKAL. | TURBID.<br>JTU | MAGNESIUM | POTASSIUM |
|----|----------|--------|-----------|----------------|-------|-------|---------|--------|----------------|-----------|-----------|
| 1  | FOND     | 700442 | 14-MAY-87 | 134.4375       | 1050  | 5     | 69.0    | 111.5  | 3.2            | 5.4       | 0.59      |
| 2  | FOND     | 700701 | 26-MAY-87 | 146.5063       | 1215  | 5     | 70.0    | 119.9  | 8.3            | 5.3       | 0.51      |
| 3  | FOND     | 701713 | 28-JUL-87 | 209.4646       | 1115  | L5.   | 80.0    | 129.4  | 2.1            | 7.5       | 0.85      |
| 4  | DISPOSAL | 700700 | 26-MAY-87 | 146.5125       | 1230  | 10    | 59.0    | 88.9   | 0.9            | 5.7       | 0.33      |
| 5  | FOND     | 701714 | 28-JUL-87 | 209.4650       | 1116  | 5     | 81.0    | 126.9  | 11.0           | 5.7       | 0.70      |
| 6  |          |        |           |                |       |       |         |        |                |           |           |
| 7  | O        | 700094 | 08-APR-87 | 98.3463        | 831   | 5     | 18.0    | 16.4   | 2.9            | 3.4       | 1.70      |
| 8  | O        | 701111 | 17-JUN-87 | 168.4604       | 1105  | 5     | 36.0    | 41.8   | 6.4            | 4.0       | 4.10      |
| 9  | O        | 701112 | 17-JUN-87 | 168.6000       | 1440  | L5.   | 37.0    | 43.4   | 1.7            | 4.0       | 3.00      |
| 10 | O        | 701113 | 17-JUN-87 | 168.6813       | 1635  | L5.   | 36.0    | 43.7   | 3.8            | 4.0       | 3.10      |
| 11 | O        | 701114 | 17-JUN-87 | 168.8479       | 2035  | 5     | 38.0    | 44.0   | 4.7            | 4.1       | 3.30      |
| 12 | O        | 701316 | 28-JUN-87 | 179.6275       | 1506  | L5.   | 47.0    | 21.6   | 2.6            | 6.8       | 4.10      |
| 13 | O        | 701317 | 28-JUN-87 | 179.6283       | 1508  | L5.   | 47.0    | 21.4   | 3.2            | 6.8       | 4.10      |
| 14 | O        | 701318 | 28-JUN-87 | 179.7563       | 1915  |       | 56.0    | 6.5    | 28.0           | 8.5       | 8.80      |
| 15 | O        | 701319 | 28-JUN-87 | 179.9208       | 2210  | 5     | 54.0    | 15.7   | 2.9            | 6.4       | 5.20      |
| 16 | O        | 701320 | 29-JUN-87 | 180.0479       | 115   | 5     | 51.0    | 19.4   | 2.3            | 7.9       | 5.10      |
| 17 | O        | 701321 | 29-JUN-87 | 180.1771       | 425   | L5.   | 49.0    | 22.1   | 2.8            | 7.5       | 5.00      |
| 18 | O        | 701322 | 29-JUN-87 | 180.2667       | 640   | L5.   | 49.0    | 24.2   | 1.5            | 7.5       | 4.40      |
| 19 | O        | 701335 | 29-JUN-87 | 180.5417       | 1300  | L5.   | 44.0    | 27.4   | 1.8            | 6.7       | 3.60      |
| 20 | O        | 701336 | 29-JUN-87 | 180.6250       | 1500  | L5.   | 43.0    | 30.3   | 1.6            | 6.0       | 3.00      |
| 21 | O        | 701337 | 29-JUN-87 | 180.8333       | 2000  | L5.   | 40.0    | 33.1   | 1.8            | 5.4       | 2.80      |
| 22 | O        | 701339 | 30-JUN-87 | 181.1771       | 425   | L5.   | 37.0    | 34.3   | 1.6            | 4.6       | 2.20      |
| 23 | O        | 701338 | 30-JUN-87 | 181.5167       | 1240  | L5.   | 38.0    | 33.8   | 1.7            | 4.8       | 2.40      |
| 24 | O        | 701819 | 03-AUG-87 | 215.1875       | 450   | 50    | 35.7    | 23.8   | 32.0           | 5.3       | 2.80      |
| 25 | O        | 701818 | 03-AUG-87 | 215.3458       | 830   | 5     | 41.0    | 27.8   | 8.7            | 5.9       | 2.80      |
| 26 | O        | 701816 | 03-AUG-87 | 216.0125       | 2430  | 5     | 41.0    | 30.0   | 4.1            | 5.9       | 2.40      |
| 27 | O        | 701854 | 04-AUG-87 | 216.1775       | 426   | L5.   | 43.0    | 40.8   | 1.7            | 5.5       | 2.00      |
| 28 | O        | 701851 | 04-AUG-87 | 216.1796       | 431   | 5     | 42.0    | 33.4   | 4.5            | 5.9       | 2.30      |
| 29 | O        | 701855 | 04-AUG-87 | 216.3421       | 921   | L5.   | 43.0    | 42.9   | 1.7            | 5.4       | 2.00      |
| 30 | O        | 701852 | 04-AUG-87 | 216.3463       | 831   | L5.   | 42.0    | 35.6   | 1.0            | 5.8       | 2.20      |
| 31 | O        | 701856 | 04-AUG-87 | 216.5129       | 1231  | L5.   | 43.0    | 45.0   | 2.8            | 5.4       | 2.00      |
| 32 | O        | 701853 | 04-AUG-87 | 216.5192       | 1246  | L5.   | 43.0    | 37.9   | 2.2            | 5.7       | 2.10      |
| 33 | O        | 701858 | 05-AUG-87 | 217.3463       | 831   | L5.   | 43.0    | 46.3   | 2.2            | 5.4       | 2.00      |
| 34 | O        | 701857 | 05-AUG-87 | 217.5125       | 1230  | L5.   | 43.0    | 45.5   | 2.7            | 5.4       | 2.00      |
| 35 | O        | 701859 | 05-AUG-87 | 217.5483       | 1316  | L5.   | 43.0    | 47.3   | 1.5            | 5.3       | 1.80      |
| 36 | O        | 702515 | 14-SEP-87 | 257.3338       | 901   | L5.   | 40.6    | 32.0   | 1.3            | 5.8       | 3.30      |
| 37 | O        | 702516 | 14-SEP-87 | 257.5008       | 1202  | L5.   | 40.4    | 34.7   | 1.5            | 5.8       | 3.20      |
| 38 | O        | 702514 | 14-SEP-87 | 257.6379       | 1531  | L5.   | 38.9    | 28.3   | 2.2            | 5.7       | 3.30      |
| 39 | O        | 702520 | 15-SEP-87 | 258.1675       | 402   | L5.   | 41.4    | 43.0   | 1.4            | 5.4       | 3.00      |
| 40 | O        | 702517 | 15-SEP-87 | 258.1679       | 403   | L5.   | 40.8    | 37.3   | 1.2            | 5.7       | 3.10      |
| 41 | O        | 702518 | 15-SEP-87 | 258.3342       | 802   | L5.   | 41.2    | 39.1   | 0.7            | 5.5       | 3.00      |
| 42 | O        | 702521 | 15-SEP-87 | 258.3346       | 803   | L5.   | 42.1    | 43.9   | 1.5            | 5.3       | 2.70      |
| 43 | O        | 702519 | 15-SEP-87 | 258.5008       | 1202  | L5.   | 41.4    | 40.1   | 0.7            | 5.5       | 3.10      |
| 44 | O        | 702647 | 22-SEP-87 | 265.3458       | 830   | L5.   | 37.7    | 32.7   | 1.7            | 6.0       | 3.00      |
| 45 | O        | 702650 | 22-SEP-87 | 265.3750       | 900   | L5.   | 37.9    | 35.1   | 1.6            | 6.0       | 3.10      |
| 46 | O        | 702648 | 22-SEP-87 | 265.5021       | 1205  | L5.   | 37.9    | 34.2   | 1.5            | 6.1       | 3.20      |
| 47 | O        | 702649 | 22-SEP-87 | 265.6667       | 1500  | L5.   | 37.7    | 34.7   | 1.3            | 6.0       | 2.90      |
| 48 |          |        |           |                |       |       |         |        |                |           |           |
| 49 | R        | 700097 | 08-APR-87 | 98.4588        | 1101  | L5.   | 68.0    | 5.7    | 0.7            | 12.0      | 1.80      |
| 50 | R        | 701304 | 28-JUN-87 | 179.5563       | 1335  | 5     | 72.0    | 14.2   | 2.8            | 12.0      | 6.00      |
| 51 | R        | 701305 | 28-JUN-87 | 179.6021       | 1445  | L5.   | 73.0    | 13.9   | 0.5            | 12.0      | 3.80      |
| 52 | R        | 701306 | 28-JUN-87 | 179.8458       | 2030  | L5.   | 75.0    | 13.1   | 1.1            | 12.0      | 4.30      |
| 53 | R        | 701307 | 28-JUN-87 | 179.9729       | 2335  | L5.   | 74.0    | 12.9   | 0.5            | 12.0      | 3.90      |
| 54 | R        | 702646 | 22-SEP-87 | 265.3750       | 900   | L5.   | 77.3    | 10.4   | 0.3            | 12.4      | 4.30      |

TABLE 7 MAJOR ION, NUTRIENT, AND METAL OBSERVATIONS IN 1987 REPORTED IN MG/L

|    | SODIUM | pH  | CHLORIDE<br>IC | SULPHATE<br>MTB | SULPHATE<br>IC | SILICA | S. COND.<br>USIE/CM | CARBON<br>DIS.ORG. | NITRATE<br>NITRITE | T. NITROGEN | T. PHOS. |
|----|--------|-----|----------------|-----------------|----------------|--------|---------------------|--------------------|--------------------|-------------|----------|
| 1  | 2.5    | 7.7 | 14.7           | 37.0            | 36.3           | 6.12   | 404                 | 0.7                | 11.00              | 7.70        | 0.011    |
| 2  | 2.7    | 8.3 | 14.9           | 37.1            | 35.8           | 7.04   | 423                 | 1.4                | 7.60               | 7.60        | 0.015    |
| 3  | 3.3    | 7.8 | 32.0           | 42.0            | 40.0           | 12.00  | 466                 | 0.9                | 12.00              | 12.00       | 0.013    |
| 4  | 3.4    | 8.1 | 15.1           | 41.0            | 39.3           | 7.21   | 375                 | 0.9                | 9.00               | 8.20        | 0.050    |
| 5  | 3.0    | 8.1 | 16.5           | 41.0            | 37.3           | 12.00  | 462                 | 0.9                | 12.00              | 12.00       | 0.120    |
| 6  |        |     |                |                 |                |        |                     |                    |                    |             |          |
| 7  | 1.1    | 7.0 | 12.0           | 5.6             | 4.9            | 2.95   | 156                 | 3.4                | 6.80               | 6.80        | 0.027    |
| 8  | 2.2    | 7.4 | 10.1           | 4.6             | 3.8            | 6.72   | 260                 | 1.2                | 19.00              | 29.00       | 0.033    |
| 9  | 2.2    | 7.3 | 10.0           | 4.6             | 3.9            | 7.04   | 263                 | 1.5                | 18.00              | 26.00       | 0.018    |
| 10 | 2.2    | 7.3 | 10.1           | 4.5             | 3.9            | 6.21   | 263                 | 1.4                | 18.00              | 18.00       | 0.018    |
| 11 | 2.2    | 7.3 | 10.1           | 4.5             | 3.9            | 5.80   | 267                 | 1.5                | 19.00              | 27.00       |          |
| 12 | 2.8    | 7.1 | 22.0           | 8.2             | 7.9            | 7.10   | 361                 | 2.2                | 29.00              | 29.00       |          |
| 13 | 2.7    | 7.1 | 22.0           | 8.2             | 7.3            | 7.20   | 360                 | 2.0                | 29.00              | 29.00       |          |
| 14 | 2.8    | 6.2 | 31.0           | 15.2            | 14.0           | 5.48   | 440                 | 3.2                | 36.00              | 39.00       |          |
| 15 | 2.9    | 6.7 | 28.0           | 11.4            | 9.5            | 6.08   | 414                 | 2.7                | 34.00              | 35.00       |          |
| 16 | 2.9    | 6.7 | 25.0           | 9.6             | 8.5            | 6.51   | 388                 | 2.4                | 31.00              | 32.00       |          |
| 17 | 2.9    | 7.0 | 23.0           | 9.0             | 8.2            | 6.66   | 371                 | 2.2                | 30.00              | 30.00       |          |
| 18 | 2.8    | 7.0 | 22.6           | 8.7             | 7.8            | 6.78   | 361                 | 2.0                | 29.00              | 29.00       | 0.019    |
| 19 | 3.0    | 7.3 | 20.0           | 7.4             | 7.2            | 6.83   | 354                 | 1.8                | 27.00              | 35.00       | 0.013    |
| 20 | 2.8    | 7.5 | 18.3           | 4.1             | 6.4            | 7.02   | 331                 | 2.2                | 25.00              | 32.00       | 0.018    |
| 21 | 2.8    | 7.5 | 15.8           | 5.8             | 5.5            | 7.00   | 304                 | 1.6                | 23.00              | 23.00       | 0.019    |
| 22 | 2.7    | 7.7 | 13.3           | 5.0             | 4.6            | 6.98   | 275                 | 1.8                | 20.00              | 19.00       | 0.016    |
| 23 | 2.7    | 7.7 | 14.0           | 5.3             | 4.9            | 7.10   | 285                 | 1.8                | 21.00              | 19.00       | 0.130    |
| 24 | 2.9    | 7.4 | 13.4           | 8.7             | 8.0            | 7.30   | 286                 | 3.4                | 20.00              | 20.00       | 0.034    |
| 25 | 2.9    | 7.6 | 16.4           | 7.1             | 6.8            | 8.80   | 317                 | 2.6                | 23.00              | 23.00       |          |
| 26 | 2.9    | 7.7 | 16.7           | 6.8             | 6.6            | 9.20   | 319                 | 2.1                | 24.00              | 24.00       | 0.013    |
| 27 | 3.0    | 7.2 | 15.2           | 5.8             | 5.6            | 10.10  | 314                 | 1.8                | 21.00              | 24.00       | 0.015    |
| 28 | 3.0    | 7.5 | 16.2           | 6.9             | 6.4            | 9.60   | 321                 | 1.8                | 23.00              | 23.00       | 0.013    |
| 29 | 3.1    | 7.5 | 14.7           | 5.4             | 5.5            | 10.10  | 312                 | 1.4                | 20.00              | 20.00       | 0.016    |
| 30 | 3.0    | 7.2 | 16.1           | 6.5             | 6.4            | 9.60   | 320                 | 1.8                | 22.00              | 22.00       | 0.020    |
| 31 | 3.0    | 7.4 | 14.7           | 5.4             | 5.6            | 9.60   | 317                 | 1.6                | 20.00              | 20.00       | 0.015    |
| 32 | 3.1    | 7.6 | 15.6           | 6.1             | 6.0            | 10.10  | 317                 | 1.7                | 23.50              | 26.00       | 0.013    |
| 33 | 3.0    | 7.9 | 14.5           | 5.2             | 5.1            | 9.60   | 321                 | 1.6                | 20.00              | 23.00       | 0.015    |
| 34 | 3.0    | 7.6 | 14.7           | 5.4             | 5.3            | 9.60   | 319                 | 1.6                | 21.00              | 26.00       | 0.012    |
| 35 | 3.0    | 8.0 | 14.3           | 4.8             | 4.8            | 8.80   | 317                 | 1.8                | 20.00              | 23.00       | 0.023    |
| 36 | 2.8    | 6.7 | 16.9           | 8.5             | 7.8            | 8.20   | 309                 | 2.4                | 21.00              | 28.00       | 0.020    |
| 37 | 2.9    | 7.0 | 16.2           | 8.1             | 7.7            | 8.20   | 311                 | 2.3                | 21.00              | 26.00       | 0.042    |
| 38 | 2.7    | 6.7 | 17.2           | 9.5             | 8.0            | 8.20   | 304                 | 2.7                | 21.00              | 24.00       | 0.020    |
| 39 | 3.0    | 7.2 | 15.3           | 7.1             | 6.5            | 8.50   | 314                 | 1.9                | 21.00              | 21.00       | 0.018    |
| 40 | 3.0    | 7.1 | 16.1           | 7.9             | 7.4            | 8.50   | 311                 | 2.2                | 21.00              | 21.00       | 0.017    |
| 41 | 3.0    | 7.3 | 15.5           | 7.5             | 6.9            | 8.50   | 313                 | 2.1                | 20.00              | 20.00       | 0.017    |
| 42 | 3.0    | 7.2 | 14.6           | 6.6             | 6.3            | 8.80   | 317                 | 1.9                | 20.00              | 20.00       | 0.015    |
| 43 | 3.0    | 7.5 | 15.6           | 7.3             | 6.7            | 8.50   | 313                 | 1.9                | 21.00              | 21.00       | 0.020    |
| 44 | 2.9    | 7.1 | 6.8            | 8.5             | 6.6            | 8.00   | 312                 | 2.3                | 21.00              | 30.00       | 0.024    |
| 45 | 2.9    | 6.8 | 19.5           | 3.8             | 3.7            | 8.00   | 313                 | 4.9                | 20.00              | 28.00       | 0.018    |
| 46 | 2.9    | 7.2 | 33.0           | 9.7             | 7.3            | 8.00   | 311                 | 2.7                | 21.00              | 28.00       | 0.017    |
| 47 | 3.0    | 6.9 | 33.0           | 8.5             | 7.4            | 8.40   | 312                 | 2.8                | 21.00              | 30.00       | 0.018    |
| 48 |        |     |                |                 |                |        |                     |                    |                    |             |          |
| 49 | 1.8    | 6.6 | 32.5           | 5.6             | 7.1            | 4.32   | 342                 | 1.4                | 46.00              | 46.00       |          |
| 50 | 2.8    | 6.8 | 31.0           | 5.6             | 4.9            | 6.18   | 368                 |                    | 53.00              | 54.00       |          |
| 51 | 2.8    | 7.0 | 31.0           | 5.6             | 4.6            | 6.14   | 363                 | 1.6                | 53.00              | 59.00       |          |
| 52 | 2.8    | 7.2 | 32.0           | 5.7             | 5.1            | 6.21   | 384                 | 1.5                | 60.00              | 57.00       |          |
| 53 | 2.8    | 6.9 | 32.0           | 5.2             | 4.6            | 6.27   | 379                 | 1.2                | 53.00              | 26.00       | 0.003    |
| 54 | 3.0    | 6.6 | 32.0           | 79.1            | 1.6            | 7.00   | 398                 | 3.2                | 58.00              | 89.00       | 0.002    |

TABLE 7 MAJOR ION, NUTRIENT, AND METAL OBSERVATIONS IN 1987 REPORTED IN MG/L

|    | COPPER | LEAD  | ZINC | IRON | MANGANESE | ALUMINUM | CADMIUM | RESIDUE<br>NON-FILT. |
|----|--------|-------|------|------|-----------|----------|---------|----------------------|
| 1  | L.002  | L.002 | 0.02 | 0.14 | L.01      | 0.100    | L.001   | 22.0                 |
| 2  | L.002  | L.002 | 0.01 | 0.29 | 0.01      | 0.300    | L.001   | 11.8                 |
| 3  | L.002  | L.002 | 0.02 |      | L.01      | 0.100    | L.001   |                      |
| 4  | L.002  | L.002 | L.01 |      | 0.02      | 0.010    | L.001   | 21.0                 |
| 5  | L.002  | L.002 | 0.03 | 0.31 | 0.03      |          | L.001   |                      |
| 6  |        |       |      |      |           |          |         |                      |
| 7  |        |       |      |      |           |          |         |                      |
| 8  |        |       |      |      |           |          |         |                      |
| 9  |        |       |      |      |           |          |         |                      |
| 10 |        |       |      |      |           |          |         |                      |
| 11 |        |       |      |      |           |          |         |                      |
| 12 |        |       |      |      |           |          |         |                      |
| 13 |        |       |      |      |           |          |         |                      |
| 14 |        |       |      |      |           |          |         |                      |
| 15 |        |       |      |      |           |          |         |                      |
| 16 |        |       |      |      |           |          |         |                      |
| 17 |        |       |      |      |           |          |         |                      |
| 18 |        |       |      |      |           |          |         |                      |
| 19 |        |       |      |      |           |          |         |                      |
| 20 |        |       |      |      |           |          |         |                      |
| 21 |        |       |      |      |           |          |         |                      |
| 22 |        |       |      |      |           |          |         |                      |
| 23 |        |       |      |      |           |          |         |                      |
| 24 |        |       |      |      |           |          |         |                      |
| 25 |        |       |      |      |           |          |         |                      |
| 26 |        |       |      |      |           |          |         |                      |
| 27 |        |       |      |      |           |          |         |                      |
| 28 |        |       |      |      |           |          |         |                      |
| 29 |        |       |      |      |           |          |         |                      |
| 30 |        |       |      |      |           |          |         |                      |
| 31 |        |       |      |      |           |          |         |                      |
| 32 |        |       |      |      |           |          |         |                      |
| 33 |        |       |      |      |           |          |         |                      |
| 34 |        |       |      |      |           |          |         |                      |
| 35 |        |       |      |      |           |          |         |                      |
| 36 | L.002  | L.002 | L.01 |      | 0.01      | 0.060    | L.001   | L10.                 |
| 37 | L.002  | L.002 | L.01 | 0.12 | 0.03      | 0.140    | L.001   | L10.                 |
| 38 | L.002  | L.002 | L.01 | 0.12 | 0.03      | 0.110    | L.001   | L10.                 |
| 39 |        |       |      |      |           |          |         |                      |
| 40 | L.002  | L.002 | L.01 |      | 0.02      | 0.042    | L.001   | L10.                 |
| 41 |        |       |      |      |           |          |         |                      |
| 42 |        |       |      |      |           |          |         |                      |
| 43 | 0.005  | L.002 | L.01 |      | L.01      | 0.072    | L.001   | L10.                 |
| 44 | L.002  | L.002 | L.01 | 0.11 | 0.01      | 0.130    | L.001   | L10.                 |
| 45 | 0.015  | L.002 | L.01 |      | 0.01      | 0.067    | L.001   | L10.                 |
| 46 | 0.009  | L.002 | L.01 |      | 0.01      | 0.052    | L.001   | L10.                 |
| 47 |        |       |      |      |           |          |         |                      |
| 48 |        |       |      |      |           |          |         |                      |
| 49 |        |       |      |      |           |          |         |                      |
| 50 |        |       |      |      |           |          |         |                      |
| 51 |        |       |      |      |           |          |         |                      |
| 52 |        |       |      |      |           |          |         |                      |
| 53 | 0.005  | L.002 | 0.03 |      | 0.07      | 0.130    | L.001   | L10.                 |
| 54 | L.002  | L.002 | 0.01 |      | 0.05      | 0.076    | L.001   | L10.                 |

TABLE 7 MAJOR ION, NUTRIENT, AND METAL OBSERVATIONS IN 1987 REPORTED IN MG/L

|     | SITE | SAMPLE | S DATE    | JULIAN DATE | STIME | COLOR | CALCIUM | ALKAL. | TURBID. JTU | MAGNESIUM | POTASSIUM |
|-----|------|--------|-----------|-------------|-------|-------|---------|--------|-------------|-----------|-----------|
| 55  | R    | 702643 | 22-SEP-87 | 265.3833    | 920   | L5.   | 79.4    | 10.4   | 0.4         | 12.2      | 4.10      |
| 56  | R    | 702644 | 22-SEP-87 | 265.5438    | 1305  | L5.   | 77.3    | 10.5   | 0.3         | 12.4      | 4.10      |
| 57  | R    | 702645 | 22-SEP-87 | 265.5667    | 1600  | L5.   | 78.1    | 10.6   | 0.3         | 12.4      | 4.50      |
| 58  | R    | 702721 | 04-OCT-87 | 277.3875    | 930   | L5.   | 81.9    | 15.6   | 0.4         | 13.0      | 4.60      |
| 59  | R    | 702722 | 04-OCT-87 | 277.5542    | 1330  | L5.   | 83.1    | 14.2   | 1.6         | 13.3      | 6.10      |
| 60  | R    | 702723 | 04-OCT-87 | 277.6792    | 1630  | L5.   | 81.9    | 12.6   | 1.2         | 13.4      | 4.50      |
| 61  | R    | 702724 | 04-OCT-87 | 277.8396    | 2015  | L5.   | 82.5    | 11.4   | 1.2         | 13.7      | 4.30      |
| 62  | R    | 702725 | 04-OCT-87 | 278.0000    | 2400  | L5.   | 82.1    | 10.5   | 0.8         | 14.1      | 4.50      |
| 63  | R    | 702726 | 05-OCT-87 | 278.1688    | 405   | L5.   | 83.8    | 8.5    | 1.0         | 14.6      | 4.60      |
| 64  | R    | 702727 | 05-OCT-87 | 278.3875    | 930   | L5.   | 84.4    | 8.0    | 0.5         | 17.7      | 4.30      |
| 65  | R    | 702728 | 05-OCT-87 | 278.5542    | 1330  | L5.   | 83.4    | 7.9    | 0.4         | 14.7      | 5.10      |
| 66  | R    | 702759 | 05-OCT-87 | 278.6796    | 1631  | L5.   | 82.6    | 8.3    | 0.5         | 14.8      | 4.30      |
| 67  | R    | 702760 | 05-OCT-87 | 278.8338    | 2001  | L5.   | 83.0    | 8.1    | 0.5         | 14.6      | 4.20      |
| 68  | R    | 702761 | 05-OCT-87 | 278.9817    | 2356  | L5.   | 82.3    | 8.3    | 0.4         | 14.7      | 4.90      |
| 69  | R    | 702762 | 06-OCT-87 | 279.1483    | 356   | L5.   | 80.7    | 8.5    | 0.3         | 14.6      | 4.30      |
| 70  | R    | 702763 | 06-OCT-87 | 279.3338    | 901   | L5.   | 81.2    | 9.6    | 0.4         | 13.4      | 3.80      |
| 71  | R    | 702764 | 06-OCT-87 | 279.5421    | 1301  | L5.   | 82.0    | 9.1    | 1.3         | 13.5      | 4.50      |
| 72  | R    | 702765 | 06-OCT-87 | 279.6671    | 1601  | L5.   | 80.3    | 9.4    | 0.3         | 13.4      | 3.80      |
| 73  | R    | 702766 | 06-OCT-87 | 279.8338    | 2001  | L5.   | 81.2    | 9.5    | 0.3         | 13.3      | 3.90      |
| 74  |      |        |           |             |       |       |         |        |             |           |           |
| 75  | P    | 700095 | 08-APR-87 | 98.3942     | 946   | L5.   | 65.0    | 2.6    | 2.5         | 18.0      | 3.40      |
| 76  | P    | 702642 | 22-SEP-87 | 265.3750    | 900   | L5.   | 66.1    | 7.0    | 1.0         | 18.2      | 7.60      |
| 77  | P    | 702639 | 22-SEP-87 | 265.4167    | 1000  | L5.   | 66.3    | 7.7    | 1.2         | 17.7      | 8.40      |
| 78  | P    | 702640 | 22-SEP-87 | 265.5583    | 1340  | L5.   | 65.4    | 7.6    | 1.3         | 18.0      | 8.20      |
| 79  | P    | 702641 | 22-SEP-87 | 265.6667    | 1600  | L5.   | 65.7    | 7.5    | 1.4         | 18.2      | 7.80      |
| 80  |      |        |           |             |       |       |         |        |             |           |           |
| 81  | S    | 700096 | 08-APR-87 | 98.4296     | 1031  | L5.   | 75.0    | 23.6   | 1.4         | 13.0      | 1.70      |
| 82  | S    | 701115 | 17-JUN-87 | 168.4167    | 1000  | L5.   | 74.0    | 118.9  | 0.7         | 5.4       | 0.52      |
| 83  | S    | 701116 | 17-JUN-87 | 168.5542    | 1330  | L5.   | 74.0    | 120.2  | 0.7         | 5.3       | 0.71      |
| 84  | S    | 701117 | 17-JUN-87 | 168.6667    | 1600  | L5.   | 74.0    | 122.2  | 0.2         | 5.3       | 0.69      |
| 85  | S    | 701118 | 17-JUN-87 | 168.8333    | 2000  | L5.   | 76.0    | 121.7  | 0.2         | 5.3       | 0.67      |
| 86  | S    | 701314 | 28-JUN-87 | 179.1333    | 320   | L5.   | 64.0    | 64.4   | 0.5         | 6.7       | 3.00      |
| 87  | S    | 701308 | 28-JUN-87 | 179.5917    | 1420  | L5.   | 60.0    | 54.4   | 0.6         | 6.4       | 4.90      |
| 88  | S    | 701309 | 28-JUN-87 | 179.6875    | 1650  | 5     | 58.0    | 42.3   | 7.4         | 6.9       | 5.50      |
| 89  | S    | 701310 | 28-JUN-87 | 179.6750    | 2100  | L5.   | 61.0    | 53.2   | 1.4         | 6.8       | 3.90      |
| 90  | S    | 701311 | 28-JUN-87 | 179.8758    | 2102  | L5.   | 60.0    | 53.4   | 0.8         | 6.8       | 5.30      |
| 91  | S    | 701312 | 28-JUN-87 | 179.8767    | 2104  | L5.   | 61.0    | 53.2   | 1.4         | 6.8       | 3.80      |
| 92  | S    | 701315 | 29-JUN-87 | 180.2271    | 545   | L5.   | 65.0    | 67.5   | 0.8         | 6.7       | 2.90      |
| 93  | S    | 701313 | 29-JUN-87 | 180.5083    | 1220  | L5.   | 62.0    | 58.9   | 0.8         | 6.7       | 3.50      |
| 94  | S    | 701817 | 03-AUG-87 | 215.3146    | 755   | 10    | 58.0    | 67.0   | 7.2         | 5.3       | 3.00      |
| 95  | S    | 701815 | 03-AUG-87 | 215.0000    | 2400  | L5.   |         | 75.7   | 2.7         |           | 2.70      |
| 96  | S    | 701844 | 04-AUG-87 | 216.1483    | 356   | L5.   | 70.0    | 95.6   | 0.4         | 5.7       | 1.90      |
| 97  | S    | 701813 | 04-AUG-87 | 216.1667    | 400   | L5.   | 63.3    | 84.1   | 0.7         | 9.1       | 2.30      |
| 98  | S    | 701845 | 04-AUG-87 | 216.3150    | 756   | L5.   | 69.0    | 99.0   | 0.4         | 5.5       | 1.80      |
| 99  | S    | 701814 | 04-AUG-87 | 216.3333    | 800   | L5.   |         | 97.6   | 0.6         |           | 2.10      |
| 100 | S    | 701843 | 04-AUG-87 | 216.4817    | 1156  | L5.   | 70.0    | 92.2   | 0.6         | 5.7       | 2.00      |
| 101 | S    | 701846 | 04-AUG-87 | 216.5008    | 1202  | L5.   | 71.0    | 101.0  | 0.3         | 5.9       | 1.70      |
| 102 | S    | 701847 | 05-AUG-87 | 217.1671    | 401   | L5.   | 70.0    | 102.2  | 0.3         | 5.6       | 1.70      |
| 103 | S    | 701850 | 05-AUG-87 | 217.1675    | 402   | 5     | 74.0    | 105.9  | 8.1         | 5.9       | 1.50      |
| 104 | S    | 701848 | 05-AUG-87 | 217.3338    | 901   | L5.   | 71.0    | 102.6  | 0.3         | 5.8       | 1.60      |
| 105 | S    | 701849 | 05-AUG-87 | 217.4817    | 1156  | L5.   | 73.0    | 104.6  | 0.3         | 5.8       | 1.60      |
| 106 |      |        |           |             |       |       |         |        |             |           |           |
| 107 | B    | 700098 | 08-APR-87 | 98.5129     | 1231  | 10    | 16.0    | 30.7   | 4.2         | 3.3       | 0.58      |
| 108 | B    | 700374 | 07-MAY-87 | 127.4400    | 1056  | 35    | 16.0    | 27.1   | 17.0        | 3.0       | 0.63      |

TABLE 7 MAJOR ION, NUTRIENT, AND METAL OBSERVATIONS IN 1987 REPORTED IN MG/L

|     | SODIUM | pH  | CHLORIDE<br>IC | SULPHATE<br>MTB | SULPHATE<br>IC | SILICA | S. COND.<br>USIE/CM | CARBON<br>DIS.ORG. | NITRATE<br>NITRITE | T. NITROGEN | T. PHOS. |
|-----|--------|-----|----------------|-----------------|----------------|--------|---------------------|--------------------|--------------------|-------------|----------|
| 55  | 2.9    | 7.1 | 32.0           | 7.7             | 4.8            | 6.70   | 590                 | 1.3                | 57.00              | 86.00       | 0.002    |
| 56  | 3.0    | 7.0 | 32.0           | 7.7             | 8.3            | 7.00   | 591                 | 1.6                | 57.00              | 91.00       | 0.002    |
| 57  | 2.9    | 6.5 | 32.0           | 79.1            | 8.3            | 6.90   | 594                 | 1.4                | 57.00              | 91.00       |          |
| 58  | 2.7    | 7.2 | 46.0           | 9.9             | 12.7           | 7.40   | 613                 | 1.1                | 60.00              | 78.00       |          |
| 59  | 2.7    | 6.8 | 46.0           | 9.1             | 11.8           | 7.30   | 622                 | 1.4                | 60.00              | 82.00       |          |
| 60  | 2.7    | 6.7 | 46.0           | 8.7             | 10.8           | 7.10   | 622                 | 1.1                | 60.00              | 88.00       |          |
| 61  | 2.7    | 6.5 | 41.0           | 8.3             | 9.4            | 7.10   | 628                 | 1.2                | 60.00              | 92.00       |          |
| 62  | 2.8    | 7.0 | 41.0           | 8.5             | 9.8            | 7.10   | 629                 | 1.3                | 60.00              | 86.00       |          |
| 63  | 2.8    | 6.2 | 45.0           | 7.7             | 8.8            | 6.80   | 642                 | 1.2                | 60.00              | 87.00       |          |
| 64  | 2.8    | 6.4 | 44.0           | 7.9             | 9.1            | 7.10   | 643                 | 0.9                | 60.00              | 94.00       |          |
| 65  | 2.8    | 6.3 | 43.0           | 7.9             | 8.8            | 7.10   | 641                 | 0.9                | 60.00              | 89.00       |          |
| 66  | 2.8    | 6.1 | 47.0           | 8.1             | 9.0            | 7.10   | 635                 | 1.0                | 62.00              | 89.00       |          |
| 67  | 2.8    | 6.2 | 46.0           | 8.1             | 8.6            | 7.10   | 631                 | 1.0                | 60.00              | 87.00       |          |
| 68  | 2.8    | 6.4 | 45.0           | 7.9             | 8.6            | 7.10   | 629                 | 0.9                | 62.00              | 90.00       |          |
| 69  | 2.8    | 6.8 | 46.0           | 8.1             | 8.6            | 7.40   | 631                 | 0.9                | 62.00              | 98.00       |          |
| 70  | 2.8    | 6.9 | 44.0           | 7.7             | 8.6            | 7.40   | 632                 | 1.0                | 62.00              | 86.00       |          |
| 71  | 2.9    | 6.2 | 45.0           | 7.8             | 8.8            | 7.40   | 631                 | L.5                | 64.00              | 90.00       |          |
| 72  | 2.9    | 6.3 | 44.0           | 7.7             | 8.8            | 7.40   | 631                 | L.5                | 64.00              | 89.00       |          |
| 73  | 2.9    | 6.4 | 45.0           | 7.7             | 8.8            | 7.40   | 628                 | L.5                | 64.00              | 89.00       | 0.011    |
| 74  |        |     |                |                 |                |        |                     |                    |                    |             |          |
| 75  | 2.5    | 6.5 | 5.9            | 82.0            | 76.0           | 5.44   | 576                 | 2.5                |                    | 35.00       | 0.014    |
| 76  | 3.9    | 6.1 | 63.0           | 77.2            | 80.0           | 9.00   | 580                 | 3.0                | 26.00              | 39.00       | 0.014    |
| 77  | 4.0    | 6.3 | 61.0           | 77.2            | 80.0           | 9.00   | 583                 | 3.2                | 26.00              | 39.00       | 0.013    |
| 78  | 3.8    | 6.4 | 61.0           | 77.2            | 80.0           | 9.00   | 582                 | 3.1                | 26.00              | 37.00       | 0.035    |
| 79  | 3.9    | 6.2 | 81.0           | 77.2            | 80.0           | 9.30   | 580                 | 3.2                | 26.00              | 35.00       | 0.009    |
| 80  |        |     |                |                 |                |        |                     |                    |                    |             |          |
| 81  | 2.3    | 7.1 | 30.0           | 110.0           | 103.0          | 5.16   | 541                 | 2.0                | 20.00              | 20.00       | 0.011    |
| 82  | 2.6    | 8.0 | 16.4           | 39.1            | 36.8           | 9.37   | 432                 | 0.7                | 11.00              | 15.00       | 0.008    |
| 83  | 2.6    | 7.9 | 15.8           | 38.4            | 35.9           | 9.42   | 434                 | L.5                | 12.00              | 10.00       | 0.003    |
| 84  | 2.6    | 8.0 | 15.6           | 39.2            | 35.0           | 9.33   | 434                 | L.5                | 12.00              | 11.00       | 0.003    |
| 85  | 2.6    | 8.0 | 15.9           | 39.2            | 36.0           | 9.33   | 437                 | L.5                | 12.00              | 11.00       |          |
| 86  | 2.6    | 7.1 | 14.3           | 40.3            | 35.9           | 7.80   | 414                 | 1.3                | 22.00              | 23.00       |          |
| 87  | 2.6    | 7.5 | 12.6           | 31.0            | 28.9           | 6.63   | 406                 | 1.8                | 24.00              | 26.00       |          |
| 88  | 2.5    | 7.0 | 12.8           | 33.4            | 31.2           | 6.23   | 411                 | 2.4                | 27.00              | 28.00       |          |
| 89  | 2.6    | 7.5 | 13.4           | 34.8            | 33.3           | 6.76   | 418                 | 1.8                | 24.00              | 27.00       |          |
| 90  | 2.6    | 7.7 | 13.3           | 34.3            | 33.1           | 3.22   | 417                 | 1.9                | 24.00              | 25.00       |          |
| 91  | 2.6    | 7.3 | 13.4           | 34.0            | 33.3           | 7.20   | 412                 | 1.9                | 25.00              | 25.00       |          |
| 92  | 2.7    | 7.1 | 14.5           | 41.2            | 36.7           | 8.10   | 418                 | 1.3                | 21.00              | 20.00       |          |
| 93  | 2.6    | 7.0 | 13.9           | 37.8            | 34.9           | 7.60   | 417                 | 1.5                | 23.00              | 24.00       |          |
| 94  | 2.5    | 7.4 | 12.2           | 29.4            | 28.7           | 8.80   | 377                 | 2.9                | 18.00              | 18.00       |          |
| 95  | 2.5    | 6.2 | 11.6           | 36.0            | 29.9           | 9.20   | 392                 | 2.2                | 19.00              | 20.00       | 0.002    |
| 96  | 2.9    | 7.7 | 14.0           | 29.5            | 30.0           | 10.50  | 430                 | 1.2                | 17.00              | 17.00       | 0.007    |
| 97  | 2.6    | 7.5 | 12.6           | 29.5            | 30.0           | 9.60   | 410                 | 1.4                | 19.00              | 22.00       | 0.003    |
| 98  | 2.8    | 7.5 | 14.3           | 29.5            | 31.0           | 10.50  | 432                 | 0.9                | 16.00              | 16.00       |          |
| 99  | 2.7    | 7.8 | 13.9           | 29.4            | 28.5           | 9.60   | 416                 | 1.2                | 18.00              | 18.00       | 0.007    |
| 100 | 2.8    | 7.7 | 15.9           | 30.0            | 30.8           | 10.10  | 426                 | 1.2                | 17.00              | 17.00       | 0.002    |
| 101 | 2.9    | 8.0 | 14.4           | 31.5            | 31.0           | 10.50  | 433                 | 1.0                | 16.00              | 16.00       | 0.002    |
| 102 | 2.9    | 8.1 | 14.4           | 31.5            | 32.0           | 10.50  | 435                 | 0.8                | 16.00              | 16.00       | 0.008    |
| 103 | 2.9    | 7.7 | 15.0           | 32.0            | 32.0           | 10.50  | 447                 | 0.8                | 16.50              | 24.00       | 0.002    |
| 104 | 2.9    | 8.0 | 14.8           | 32.0            | 32.0           | 10.70  | 436                 | 0.8                | 16.00              | 16.00       | 0.002    |
| 105 | 2.9    | 7.7 | 14.9           | 32.0            | 33.0           | 11.10  | 442                 | 0.8                | 18.50              | 32.00       | 0.047    |
| 106 |        |     |                |                 |                |        |                     |                    |                    |             |          |
| 107 | 1.2    | 7.1 | 1.6            | 8.2             | 7.5            | 3.70   | 116                 | 3.8                | 3.00               | 3.00        | 0.045    |
| 108 | 1.4    | 7.2 | 1.7            | 11.1            | 11.4           | 5.09   | 118                 | 3.2                | 3.40               | 3.40        | 0.037    |

TABLE 7 MAJOR ION, NUTRIENT, AND METAL OBSERVATIONS IN 1987 REPORTED IN MG/L

|     | COPPER | LEAD  | ZINC | IRON | MANGANESE | ALUMINUM | CADMIUM | RESIDUE<br>NON-FILT. |
|-----|--------|-------|------|------|-----------|----------|---------|----------------------|
| 55  | L.002  | L.002 | 0.01 |      | 0.04      | 0.080    | L.001   | L10.                 |
| 56  | 0.005  | L.002 | 0.02 |      | 0.04      | 0.140    | L.001   | L10.                 |
| 57  |        |       |      |      |           |          |         |                      |
| 58  |        |       |      |      |           |          |         |                      |
| 59  |        |       |      |      |           |          |         |                      |
| 60  |        |       |      |      |           |          |         |                      |
| 61  |        |       |      |      |           |          |         |                      |
| 62  |        |       |      |      |           |          |         |                      |
| 63  |        |       |      |      |           |          |         |                      |
| 64  |        |       |      |      |           |          |         |                      |
| 65  |        |       |      |      |           |          |         |                      |
| 66  |        |       |      |      |           |          |         |                      |
| 67  |        |       |      |      |           |          |         |                      |
| 68  |        |       |      |      |           |          |         |                      |
| 69  |        |       |      |      |           |          |         |                      |
| 70  |        |       |      |      |           |          |         |                      |
| 71  |        |       |      |      |           |          |         |                      |
| 72  |        |       |      |      |           |          |         |                      |
| 73  |        |       |      |      |           |          |         |                      |
| 74  |        |       |      |      |           |          |         |                      |
| 75  | L.002  | L.002 | 0.02 |      | 0.17      | 0.460    | L.001   | L10.                 |
| 76  | L.002  | L.002 | 0.02 |      | 0.16      | 0.380    | L.001   | L10.                 |
| 77  | 0.017  | L.002 | 0.02 |      | 0.16      | 0.380    | L.001   | L10.                 |
| 78  | L.002  | L.002 | 0.02 |      | 0.17      | 0.470    | L.001   | L10.                 |
| 79  |        |       |      |      |           |          |         |                      |
| 80  |        |       |      |      |           |          |         |                      |
| 81  |        |       |      |      |           |          |         |                      |
| 82  |        |       |      |      |           |          |         |                      |
| 83  |        |       |      |      |           |          |         |                      |
| 84  |        |       |      |      |           |          |         |                      |
| 85  |        |       |      |      |           |          |         |                      |
| 86  |        |       |      |      |           |          |         |                      |
| 87  |        |       |      |      |           |          |         |                      |
| 88  |        |       |      |      |           |          |         |                      |
| 89  |        |       |      |      |           |          |         |                      |
| 90  |        |       |      |      |           |          |         |                      |
| 91  |        |       |      |      |           |          |         |                      |
| 92  |        |       |      |      |           |          |         |                      |
| 93  |        |       |      |      |           |          |         |                      |
| 94  |        |       |      |      |           |          |         |                      |
| 95  |        |       |      |      |           |          |         |                      |
| 96  |        |       |      |      |           |          |         |                      |
| 97  |        |       |      |      |           |          |         |                      |
| 98  |        |       |      |      |           |          |         |                      |
| 99  |        |       |      |      |           |          |         |                      |
| 100 |        |       |      |      |           |          |         |                      |
| 101 |        |       |      |      |           |          |         |                      |
| 102 |        |       |      |      |           |          |         |                      |
| 103 |        |       |      |      |           |          |         |                      |
| 104 |        |       |      |      |           |          |         |                      |
| 105 |        |       |      |      |           |          |         |                      |
| 106 |        |       |      |      |           |          |         |                      |
| 107 |        |       |      |      |           |          |         |                      |
| 108 |        |       |      |      |           |          |         |                      |

TABLE 7 MAJOR ION, NUTRIENT, AND METAL OBSERVATIONS IN 1987 REPORTED IN MG/L

| SITE | SAMPLE | S DATE | JULIAN<br>DATE | STIME    | COLOR | CALCIUM | ALKAL. | TURBID.<br>JTU | MAGNESIUM | POTASSIUM |
|------|--------|--------|----------------|----------|-------|---------|--------|----------------|-----------|-----------|
| 109  | B      | 700375 | 07-MAY-87      | 127.6471 | 1553  | 15      | 17.0   | 29.0           | 7.5       | 3.0       |
| 110  | B      | 700376 | 07-MAY-87      | 127.8129 | 1951  | 10      | 17.0   | 28.6           | 6.0       | 3.0       |
| 111  | B      | 700377 | 07-MAY-87      | 127.9775 | 2346  | 10      | 17.0   | 27.7           | 5.0       | 3.0       |
| 112  | B      | 703175 | 05-NOV-87      | 309.2921 | 701   | 25      | 14.6   | 28.0           | 11.0      | 2.4       |
| 113  | B      | 703176 | 05-NOV-87      | 309.4588 | 1101  | 25      | 14.7   | 27.8           | 10.0      | 2.4       |
| 114  | B      | 703177 | 05-NOV-87      | 309.6254 | 1501  | 25      | 14.9   | 28.4           | 9.2       | 2.4       |
| 115  | B      | 703178 | 05-NOV-87      | 309.7921 | 1901  | 25      | 14.9   | 26.7           | 9.6       | 2.4       |

| SODIUM | pH  | CHLORIDE<br>IC | SULPHATE<br>MTB | SULPHATE<br>IC | SILICA | S. COND.<br>USIE/CM | CARBON<br>DIS.ORG. | NITRATE<br>NITRITE | T. NITROGEN | T. PHOS. |
|--------|-----|----------------|-----------------|----------------|--------|---------------------|--------------------|--------------------|-------------|----------|
| 109    | 1.4 | 7.3            | 1.7             | 11.3           | 11.4   | 4.99                | 123                | 3.2                | 3.80        | 3.90     |
| 110    | 1.4 | 7.4            | 1.7             | 11.5           | 11.9   | 5.24                | 123                | 3.4                | 3.80        | 4.30     |
| 111    | 1.4 | 7.4            | 1.6             | 11.5           | 11.9   | 4.99                | 123                | 2.8                | 3.80        | 4.50     |
| 112    | 1.4 | 6.8            | 0.5             | 15.9           | 15.6   | 5.50                | 104                | 3.6                | 0.72        | 0.73     |
| 113    | 1.4 | 6.9            | 0.5             | 15.7           | 15.6   | 5.50                | 103                | 3.8                | 0.70        | 0.73     |
| 114    | 1.4 | 6.9            | 0.5             | 15.7           | 15.5   | 5.50                | 104                | 3.8                | 0.68        | 0.74     |
| 115    | 1.4 | 7.2            | L.5             | 15.7           | 15.5   | 5.40                | 103                | 3.9                | 0.73        | 0.72     |

| COPPER | LEAD  | ZINC  | IRON | MANGANESE | ALUMINUM | CADMIUM | RESIDUE<br>NON-FILT. |
|--------|-------|-------|------|-----------|----------|---------|----------------------|
| 109    |       |       |      |           |          |         |                      |
| 110    |       |       |      |           |          |         |                      |
| 111    | L.002 | L.002 | 0.02 | 0.31      | L.01     | 0.300   | L.001                |
| 112    | 0.002 | L.002 | 0.02 | 0.28      | L.01     | 0.250   | L.001                |
| 113    |       | L.002 | 0.02 | 0.27      | L.01     | 0.290   | L.001                |
| 114    | 0.018 | L.002 | 0.02 | 0.27      | L.01     | 0.230   | L.001                |
| 115    |       |       |      |           |          |         |                      |

TABLE 8 PESTICIDE OBSERVATIONS RECORDED IN 1987 REPORTED IN UG/L

|    | SITE      | SAMPLE | SDATE     | JULIAN<br>DATE | STIME | DINOSES | METRIBUZINE | CHLORO-<br>THALONIL | CYPER-<br>METHRIN |
|----|-----------|--------|-----------|----------------|-------|---------|-------------|---------------------|-------------------|
| 1  | PCND      | 701715 | 28-JUL-87 | 209.4650       | 1116  | L.02    |             | L.006               |                   |
| 2  | PCND SPX. | 701716 | 28-JUL-87 | 209.4650       | 1116  | 0.29    |             | L.006               |                   |
| 3  |           |        |           |                |       |         |             |                     |                   |
| 4  | O         | 700081 | 07-APR-87 | 97.6667        | 1600  |         | 0.020       |                     |                   |
| 5  | O         | 700086 | 08-APR-87 | 98.3467        | 832   |         | L.01        |                     |                   |
| 6  | O         | 701119 | 17-JUN-87 | 168.4608       | 1106  |         | L.01        |                     |                   |
| 7  | O         | 701120 | 17-JUN-87 | 168.6004       | 1441  |         | L.01        |                     |                   |
| 8  | O         | 701121 | 17-JUN-87 | 168.6817       | 1636  |         | L.01        |                     |                   |
| 9  | O         | 701122 | 17-JUN-87 | 168.8483       | 2036  |         | L.01        |                     |                   |
| 10 | O         | 701298 | 28-JUN-87 | 179.6279       | 1507  |         | L.01        |                     |                   |
| 11 | O         | 701299 | 28-JUN-87 | 179.6288       | 1509  |         | L.01        |                     |                   |
| 12 | O         | 701300 | 28-JUN-87 | 179.7567       | 1816  |         | 0.010       |                     |                   |
| 13 | O         | 701301 | 28-JUN-87 | 179.9213       | 2211  |         | L.01        |                     |                   |
| 14 | O         | 701302 | 29-JUN-87 | 180.0483       | 116   |         | L.01        |                     |                   |
| 15 | O         | 701303 | 29-JUN-87 | 180.2671       | 641   | L.02    |             |                     |                   |
| 16 | O         | 701824 | 03-AUG-87 | 215.1879       | 451   | L.02    |             |                     |                   |
| 17 | O         | 701825 | 03-AUG-87 | 215.3463       | 831   | L.02    |             |                     |                   |
| 18 | O         | 701827 | 03-AUG-87 | 216.0129       | 2431  | L.02    |             |                     |                   |
| 19 | O         | 701837 | 04-AUG-87 | 216.1771       | 425   | L.02    |             |                     |                   |
| 20 | O         | 701835 | 04-AUG-87 | 216.1792       | 430   | L.02    |             |                     |                   |
| 21 | O         | 701838 | 04-AUG-87 | 216.3417       | 820   | L.02    |             |                     |                   |
| 22 | O         | 701826 | 04-AUG-87 | 216.3458       | 830   | L.02    |             |                     |                   |
| 23 | O         | 701839 | 04-AUG-87 | 216.5125       | 1230  | L.02    |             |                     |                   |
| 24 | O         | 701836 | 04-AUG-87 | 216.5188       | 1245  | L.02    |             |                     |                   |
| 25 | O         | 701840 | 05-AUG-87 | 217.1792       | 430   | L.02    |             |                     |                   |
| 26 | O         | 701841 | 05-AUG-87 | 217.3458       | 830   | L.02    |             |                     |                   |
| 27 | O         | 701842 | 05-AUG-87 | 217.5479       | 1315  | L.02    |             |                     |                   |
| 28 | O         | 702512 | 14-SEP-87 | 257.3333       | 800   |         |             | L.002               |                   |
| 29 | O         | 702513 | 14-SEP-87 | 257.5004       | 1201  |         |             | L.002               |                   |
| 30 | O         | 702511 | 14-SEP-87 | 257.6375       | 1530  |         |             | 0.005               |                   |
| 31 | O         | 702506 | 15-SEP-87 | 258.1667       | 400   |         |             | 0.007               |                   |
| 32 | O         | 702509 | 15-SEP-87 | 258.1671       | 401   |         |             | L.002               |                   |
| 33 | O         | 702507 | 15-SEP-87 | 258.3333       | 800   |         |             | L.002               |                   |
| 34 | O         | 702510 | 15-SEP-87 | 258.3338       | 801   |         |             | 0.004               |                   |
| 35 | O         | 702508 | 15-SEP-87 | 258.5004       | 1201  |         |             | L.002               |                   |
| 36 | O         | 702661 | 22-SEP-87 | 265.1667       | 400   |         | L.01        |                     |                   |
| 37 | O         | 702659 | 22-SEP-87 | 265.3463       | 831   |         | L.01        |                     |                   |
| 38 | O         | 702662 | 22-SEP-87 | 265.3754       | 901   |         | L.01        |                     |                   |
| 39 | O         | 702660 | 22-SEP-87 | 265.5025       | 1206  |         |             |                     |                   |
| 40 |           |        |           |                |       |         |             |                     |                   |
| 41 | R         | 700084 | 07-APR-87 | 97.6021        | 1445  | 0.11    |             |                     |                   |
| 42 | R         | 700089 | 08-APR-87 | 98.4583        | 1100  | 0.14    |             |                     |                   |
| 43 | R         | 701286 | 28-JUN-87 | 179.5567       | 1336  | L.02    | L.01        |                     |                   |
| 44 | R         | 701287 | 28-JUN-87 | 179.6025       | 1446  | L.02    | L.01        |                     |                   |
| 45 | R         | 701288 | 28-JUN-87 | 179.8463       | 2031  | L.02    | L.01        |                     |                   |
| 46 | R         | 701289 | 28-JUN-87 | 179.9733       | 2336  | L.02    | L.01        |                     |                   |
| 47 | R         | 702502 | 14-SEP-87 | 257.7083       | 1700  | 44.00   |             |                     |                   |
| 48 | R         | 702657 | 22-SEP-87 | 265.1667       | 400   | 1.40    |             |                     |                   |
| 49 | R         | 702658 | 22-SEP-87 | 265.3754       | 901   | 2.00    |             |                     |                   |
| 50 | R         | 702655 | 22-SEP-87 | 265.3836       | 921   | 1.74    |             |                     |                   |
| 51 | R         | 702656 | 22-SEP-87 | 265.5442       | 1306  | 1.71    |             |                     |                   |
| 52 | R         | 702736 | 23-SEP-87 | 266.5004       | 1201  | 0.58    |             |                     |                   |
| 53 | R         | 702737 | 23-SEP-87 | 266.5021       | 1205  | 0.59    |             |                     |                   |
| 54 | R         | 702738 | 23-SEP-87 | 266.5042       | 1210  | 0.81    |             |                     |                   |

TABLE 8 PESTICIDE OBSERVATIONS RECORDED IN 1987 REPORTED IN UG/L

|     | SITE | SAMPLE | S DATE    | JULIAN<br>DATE | STIME | DINOSB | METRIBUZINE | CHLORO-<br>THALONIL | CYPER-<br>METHRIN |
|-----|------|--------|-----------|----------------|-------|--------|-------------|---------------------|-------------------|
| 55  | R    | 702739 | 23-SEP-87 | 266.5083       | 1220  | 1.20   |             |                     |                   |
| 56  | R    | 702743 | 04-OCT-87 | 277.3879       | 931   | 0.88   |             |                     |                   |
| 57  | R    | 702744 | 04-OCT-87 | 277.5546       | 1331  | 1.00   |             |                     |                   |
| 58  | R    | 702745 | 04-OCT-87 | 277.6796       | 1631  | 0.91   |             |                     |                   |
| 59  | R    | 702746 | 04-OCT-87 | 277.8400       | 2016  | 0.47   |             |                     |                   |
| 60  | R    | 702747 | 04-OCT-87 | 278.0004       | 2401  | 0.43   |             |                     |                   |
| 61  | R    | 702748 | 05-OCT-87 | 278.1692       | 406   | 0.43   |             |                     |                   |
| 62  | R    | 702749 | 05-OCT-87 | 278.3879       | 931   | 0.34   |             |                     |                   |
| 63  | R    | 702750 | 05-OCT-87 | 278.5546       | 1331  | 0.35   |             |                     |                   |
| 64  | R    | 702751 | 05-OCT-87 | 278.6792       | 1630  | 0.32   |             |                     |                   |
| 65  | R    | 702752 | 05-OCT-87 | 278.8333       | 2000  | 0.19   |             |                     |                   |
| 66  | R    | 702753 | 05-OCT-87 | 278.9813       | 2355  | 0.19   |             |                     |                   |
| 67  | R    | 702754 | 06-OCT-87 | 279.1479       | 355   | 0.24   |             |                     |                   |
| 68  | R    | 702755 | 06-OCT-87 | 279.3333       | 800   | 0.20   |             |                     |                   |
| 69  | R    | 702756 | 06-OCT-87 | 279.5417       | 1300  | 0.17   |             |                     |                   |
| 70  | R    | 702757 | 06-OCT-87 | 279.6667       | 1600  | 0.21   |             |                     |                   |
| 71  | R    | 702758 | 06-OCT-87 | 279.8333       | 2000  | 0.20   |             |                     |                   |
| 72  |      |        |           |                |       |        |             |                     |                   |
| 73  | P    | 700082 | 07-APR-87 | 97.6854        | 1645  | 1.10   |             |                     |                   |
| 74  | P    | 700087 | 08-APR-87 | 98.3946        | 947   | 0.83   |             |                     |                   |
| 75  | P    | 702654 | 22-SEP-87 | 265.3754       | 901   | 0.23   |             |                     |                   |
| 76  | P    | 702651 | 22-SEP-87 | 265.4171       | 1001  | 0.20   |             |                     |                   |
| 77  | P    | 702652 | 22-SEP-87 | 265.5588       | 1341  | 0.22   |             |                     |                   |
| 78  | P    | 702653 | 22-SEP-87 | 265.6671       | 1601  | 0.14   |             |                     |                   |
| 79  |      |        |           |                |       |        |             |                     |                   |
| 80  | S    | 700083 | 07-APR-87 | 97.6313        | 1515  | 0.17   |             |                     |                   |
| 81  | S    | 700088 | 08-APR-87 | 98.4292        | 1030  | 0.20   |             |                     |                   |
| 82  | S    | 701123 | 17-JUN-87 | 168.4171       | 1001  | L.02   |             |                     |                   |
| 83  | S    | 701124 | 17-JUN-87 | 168.5546       | 1331  | L.02   |             |                     |                   |
| 84  | S    | 701125 | 17-JUN-87 | 168.6671       | 1601  | L.02   |             |                     |                   |
| 85  | S    | 701126 | 17-JUN-87 | 168.8338       | 2001  | L.02   |             |                     |                   |
| 86  | S    | 701290 | 28-JUN-87 | 179.5921       | 1421  | 0.14   |             |                     |                   |
| 87  | S    | 701291 | 28-JUN-87 | 179.6879       | 1651  | 0.57   |             |                     |                   |
| 88  | S    | 701292 | 28-JUN-87 | 179.8754       | 2101  | 0.14   |             |                     |                   |
| 89  | S    | 701293 | 28-JUN-87 | 179.8771       | 2105  | 0.18   |             |                     |                   |
| 90  | S    | 701294 | 28-JUN-87 | 179.8792       | 2110  | 0.10   |             |                     |                   |
| 91  | S    | 701296 | 29-JUN-87 | 180.1333       | 320   | 0.08   |             |                     |                   |
| 92  | S    | 701297 | 29-JUN-87 | 180.2275       | 546   | 0.06   |             |                     |                   |
| 93  | S    | 701295 | 29-JUN-87 | 180.5088       | 1221  | 0.12   |             |                     |                   |
| 94  | S    | 701820 | 03-AUG-87 | 215.3150       | 756   |        |             |                     | L.01              |
| 95  | S    | 701831 | 03-AUG-87 | 216.0004       | 2401  |        |             |                     | L.01              |
| 96  | S    | 701822 | 04-AUG-87 | 216.1479       | 355   |        |             |                     | L.01              |
| 97  | S    | 701828 | 04-AUG-87 | 216.1671       | 401   |        |             |                     | L.01              |
| 98  | S    | 701823 | 04-AUG-87 | 216.3146       | 755   |        |             |                     | L.01              |
| 99  | S    | 701829 | 04-AUG-87 | 216.3338       | 801   |        |             |                     | L.01              |
| 100 | S    | 701821 | 04-AUG-87 | 216.4813       | 1155  |        |             |                     | L.01              |
| 101 | S    | 701830 | 04-AUG-87 | 216.5004       | 1201  |        |             |                     | L.01              |
| 102 | S    | 701832 | 05-AUG-87 | 217.1667       | 400   |        |             |                     | L.01              |
| 103 | S    | 701833 | 05-AUG-87 | 217.3333       | 800   |        |             |                     | L.01              |
| 104 | S    | 701834 | 05-AUG-87 | 217.4813       | 1155  |        |             |                     | L.01              |
| 105 | S    | 702503 | 14-SEP-87 | 257.7208       | 1730  | 0.44   |             |                     |                   |
| 106 | S    | 702504 | 14-SEP-87 | 257.7229       | 1735  | 0.42   |             |                     |                   |
| 107 | S    | 702505 | 14-SEP-87 | 257.7250       | 1740  | 0.24   |             |                     |                   |
| 108 | S    | 702740 | 23-SEP-87 | 266.7271       | 1745  | 0.05   |             |                     |                   |

TABLE 8 PESTICIDE OBSERVATIONS RECORDED IN 1987 REPORTED IN UG/L

|     | SITE | SAMPLE | SDATE     | JULIAN<br>DATE | STIME | DINOSEB | METRIBUZINE | CHLORO-<br>THALONIL | CYPER-<br>METHRIN |
|-----|------|--------|-----------|----------------|-------|---------|-------------|---------------------|-------------------|
| 109 | S    | 702741 | 23-SEP-87 | 266.7292       | 1750  | L.02    |             |                     |                   |
| 110 | S    | 702742 | 23-SEP-87 | 266.7296       | 1751  | L.02    |             |                     |                   |
| 111 | S    | 703211 | 30-OCT-87 | 303.7083       | 1700  | L.02    |             |                     |                   |
| 112 | S    | 703212 | 30-OCT-87 | 303.7092       | 1702  | L.02    |             |                     |                   |
| 113 | S    | 703213 | 30-OCT-87 | 303.7100       | 1704  | L.02    |             |                     |                   |
| 114 | S    | 703208 | 04-NOV-87 | 308.4708       | 1130  | L.02    |             |                     |                   |
| 115 | S    | 703209 | 04-NOV-87 | 308.4717       | 1132  | L.02    |             |                     |                   |
| 116 | S    | 703210 | 04-NOV-87 | 308.4725       | 1134  | L.02    |             |                     |                   |
| 117 |      |        |           |                |       |         |             |                     |                   |
| 118 | B    | 700085 | 07-APR-87 | 97.5542        | 1330  | L.02    |             | 0.020               |                   |
| 119 | B    | 700090 | 08-APR-87 | 98.5125        | 1230  | L.02    |             | 0.020               |                   |
| 120 | B    | 700378 | 07-MAY-87 | 127.4396       | 1055  | L.02    |             | 0.010               |                   |
| 121 | B    | 700379 | 07-MAY-87 | 127.6467       | 1552  | L.02    |             | 0.010               |                   |
| 122 | B    | 700380 | 07-MAY-87 | 127.8125       | 1950  | L.02    |             | 0.010               |                   |
| 123 | B    | 700381 | 07-MAY-87 | 127.9771       | 2345  | L.02    |             | 0.010               |                   |
| 124 | B    | 703170 | 05-NOV-87 | 309.2917       | 700   | L.02    |             | 0.003               |                   |
| 125 | B    | 703171 | 05-NOV-87 | 309.2938       | 705   | L.02    |             | 0.003               |                   |
| 126 | B    | 703172 | 05-NOV-87 | 309.4583       | 1100  | L.02    |             | 0.001               |                   |
| 127 | B    | 703173 | 05-NOV-87 | 309.6250       | 1500  | L.02    |             | 0.002               |                   |
| 128 | B    | 703174 | 05-NOV-87 | 309.7917       | 1900  | L.02    |             | 0.001               |                   |